Design and Development of RFID based Library Information System

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ABSTRACT

RFID (Radio Frequency Identification) technology is an automatic identification system consisting of a tag and a reader which can communicate with radio waves. Within the business processes it is possible to read and write the data from and into the microchip included tags from long distances. In this way, with lower costs more efficient process management and monitoring is provided. Today, RFID technology can find a wide range of application areas in many sectors such as automotive, logistics, retail, healthcare and libraries. RFID can provide long term benefits to libraries in process, traceability and security. It can enhance existing barcode systems by providing additional features such as automatic checkout and return whilst adding security against theft. RFID will reduce lost books and creates savings in time spent searching for books shelved in incorrect locations. Stock-taking can be reduced to a simple walk down an isle as the RFID tags are read whilst they are still on the shelf. However RFID technology is still relatively new for library applications and there is a growing interest regarding the possibilities of using RFID technology. In this study design and development of an RFID based Library Information System (RLIS) for a Turkish library is described comprehensively.

Keywords: RFID implementation, library, design and development

1. INTRODUCTION

RFID is a promising automatic identification technology providing data transfer using radio waves. Today, RFID applications range from potential areas such as security, manufacturing, logistics, animal tagging, waste management, postal tracking to airline baggage and road toll management. The enhancement in RFID technology has brought advantages that are related to resource optimization, increased efficiency, security, visibility and accuracy within processes. And this technology is receiving an increasing attention for library information management systems in recent years.

RFID has benefits to libraries in process, traceability and security. It can enhance existing barcode systems by providing additional features such as automatic checkout and return whilst adding security against theft. It reduces lost books and creates savings in time spent searching for books shelved in incorrect locations. Time required for inventory counting can be reduced to a simple walk down an isle as the RFID tags are read whilst they are still on the shelf [1]. Since libraries first used RFID systems in the late 1990's, more and more libraries have identified the advantages of the technology.

In this paper, design and development of an RFID based Library Information System (RLIS) for a Turkish library is described comprehensively. In the following section the RFID technology and its history is explained. Then Section 3 provides an overview about the relevant literature. The architectural framework and the functionalities of components of the proposed system are introduced in Section 4 and 5 respectively. Finally, Section 6 presents the conclusions and outlines further research.

2. RFID TECHNOLOGY AND ITS HISTORY

RFID technology is a wireless sensor technology which is based on the detection of electromagnetic signals. A typical RFID system consists of three components: a transponder or a tag, an interrogator and a controller (Figure 1).

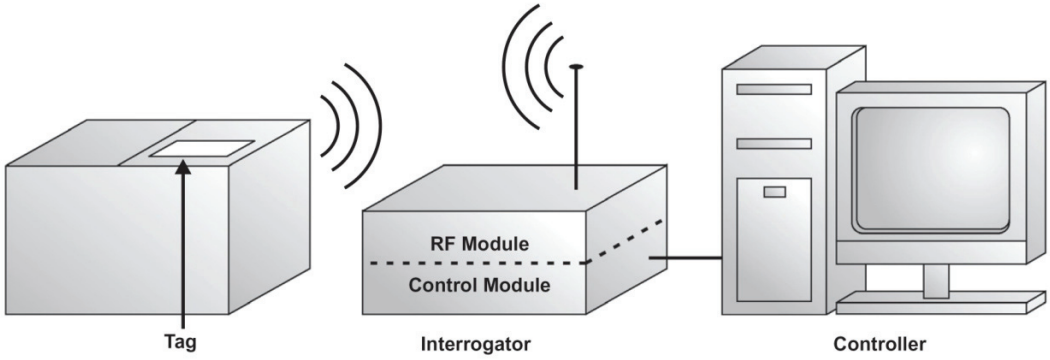

Figure 1. A typical RFID system [10]

The tag and the interrogator communicate information between one another via radio waves. When a tagged object enters the read zone of an interrogator, the interrogator signals the tag to transmit its stored data. Once the data on the tag is received by the interrogator, the information is relayed back to the controller via a network interface. The controller can then use that information for a variety of purposes.

The frequency of RFID tags can be classified into low frequency (LF), high frequency (HF), ultrahigh frequency (UHF), and microwave. The HF passive tags are commonly used in libraries and bookstores for book tracking and access control; however UHF passive tags have been recently used in library applications. UHF outperforms HF in terms of its higher reading speed and longer read range. This ensures quicker multiple-item detection, as well as faster inventory checking. However, when it comes to the self-service environment in libraries, it is important that UHF RFID waves must be carefully controlled that they do not misread untargeted items nearby, and thus resulting in check-in and check-out errors [2].

The history of this technology goes back to 1939. During World War II, the British wanted to distinguish between their own returning aircrafts and those of the enemy, thus they placed transponders on their aircrafts which would be able to respond appropriately to interrogating signals from base stations. This was called the Identity Friend or Foe (IFF) system and is widely considered the first use of Radio Frequency Identification [3]. The first commercial use of the RFID began in the 1960's with the development of the Electronic Article Surveillance (EAS) equipment by the companies Sensormatic, Checkpoint and Knogo to prevent the theft of merchandise. In the 1970s developers, inventors, companies, academic institutions, and government laboratories began working actively on RFID, and notable advances were being realized at research laboratories and academic institutions. In 1990's RFID saw the wide scale deployment of electronic toll collection in the United States and the installation of over 3 million RFID tags on rail cars in North America [4]. Subsequent to the announcement of U.S. Department of Defense that RFID technology held the potential to revolutionize "In-Transit-Visibility" and the 'Total Asset Visibility" in supply chains, many technology vendors were encouraged to push forward RFID development for commercial purposes [5]. However, the value of RFID technology for managing business supply chains has only been recognized in recent years. The business press has since proclaimed that RFID marks a commercial innovation with the potential to soon replace barcode technology in the supply chains of numerous industries. Incited by those developments and promises, companies from varying industries planned RFID adoption aiming to exploit cost saving potentials and new business opportunities.

3. BACKGROUND

Since RFID technology has recently received an emerging attention, there is a growing literature on RFID technology. However, literature containing the use of RFID technology in libraries is fairly limited. The initial research studies have mainly focused on the usage details of RFID applications in libraries [6, 7]. Coyle handled the management questions that RFID surface for libraries that are considering this technology [8]. Molnar and Wagner expose privacy issues related to RFID in libraries, describe current deployments, and suggest novel architectures for library RFID [9]. Recent studies have examined the usage of HF and UHF RFID technologies together and compared the two technology platforms in terms of benefits and weaknesses [10, 11].

This study contributes to RFID literature regarding to library information management system. We describe the design and development of an RFID based Library Information System for a Turkish library.

4. ARCHITECTURE OF THE RLIS

In this section, the architectural overview of the RLIS is explained in detailed. The architectural framework designed and developed using RFID technology, comprises five cross-sectional layers as demonstrated in Figure 2. The working principles of each layer are described in the following sub-sections.

4.1. Physical Layer

The first layer is a physical layer consists of UHF RFID tags attached in different items such as books, CD/DVD cases, shelves and user identification cards. The high frequency (HF) passive tags are commonly used in libraries and bookstores for book tracking and access control; however in the proposed RLIS, ultra-high frequency (UHF) passive tags are used. These UHF passive tags can operate between 860 MHz to 960 MHz and are capable of communicating with RFID readers through antennas in long distances. The UHF RFID tags can store a unique identification number which specifies either the book tracking number, library user identification number or shelf identification number. Each tag located in a book may also contain basic information about the book, such as its category, publisher name, pressing date, ISBN number, and so on.

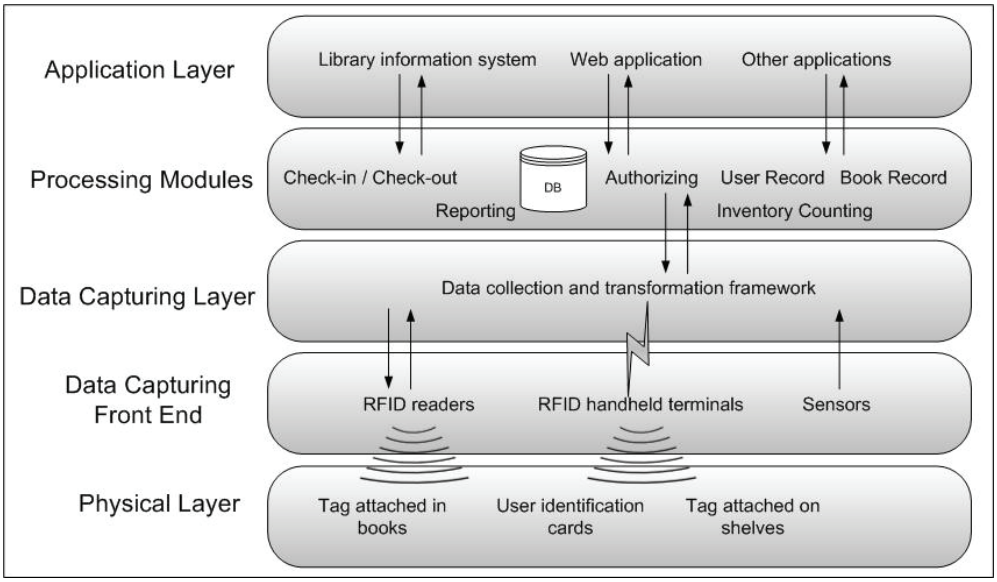

Figure 2. Architectural framework of the RLIS

4.2. Data Capturing Front End

The second layer, called data-capturing front-end system, is the layer of RFID readers. The aim of designing the data capturing front-end layer is to provide the precise real-time data for the system. Both handheld terminal and readers equipped with fixed antennas are used to communicate with UHF tags. Fixed antennas are located in entrance of the library, in service desk and in check-in/check-out desks. A handheld reader is also used to conduct a quick scan of the tags attached in books and count the number of books in a particular shelf. In this layer, in addition to the UHF RFID readers, motion-sensors are used in the entrance. Because library users can enter and exit through one door, sensors help us to determine the direction of the movement.

4.3. Data Capturing Layer

This is a middleware system that assists with the filtering, aggregation, and routing of RFID data. Data emerging from the previous layer, can be seen as a stream of RFID observations of the form (*tag_id*, *reader_id*, *timestamp*), where *tag_id* and *reader_id* refer to unique identification codes of the tagged item and the RFID reader (as well as its location), and the *timestamp* is the time when the reading occurred respectively. RFID middleware systems typically deployed between the readers and the applications in order to correct captured readings and provide clean and meaningful data to application logic. Thus, this layer is responsible for mapping the low-level data incoming from RFID readers to a more manageable form suitable for the interactions on the processing modules and enterprise application level.

4.4. Processing Modules

This layer is responsible for storing the RFID data in a relational database system, accessing the data using Structured Query Language (SQL) and processing the data by integrated processing modules. These modules are designed as Check-in/Check-out, Reporting, Authorizing, Inventory Counting, User Record and Book Record. They can interact with the middleware system by issuing simple queries as well as by installing standing queries that result in a stream of matching data.

4.5. Application Layer

Above the processing modules, there is an application layer which is used to coordinate and integrate the processing modules and manage data flows within the new library information management system and the existing system applications. This layer provides the user-friendly graphical interfaces for the library staff to use the modules and also supports the other enterprise and web applications.

5. SYSTEM ANALYSIS AND DESIGN OF THE RLIS

In this stage, we aimed at understanding the current processes and operations in the library environment and develop system architecture. We therefore conducted interviews with the staff working in the library, with the aim of observing their operations at the same time. Having learned about the business processes and operational environment in the library, we then analyzed business needs and functional key requirements for RLIS. After our system analysis, we developed the system architecture which provides a road map for the system-building process. In the system overview, the subsystems are identified and a framework among subsystem controls and

communications is established. Moreover, the functionalities of the components are defined and communication interfaces between one component and another are described. The mapping between the system and business processes is used to guide application development and ensure proper integration.

An overview of the system is shown in Figure 3. It depicts an RLIS system consisting of six main subsystems: New User Record, Tagging, Check-in/Check-out, Anti-theft Detection, Inventory Control and Administration. All these subsystems are linked up through a wired or wireless network and connected to the main server. We describe each of the key subsystems below.

(i) *New User Record.* The library users would be required to carry an RFID attached member identification card. This subsystem is for new user registration and enables staff to print out new UHF tags. A PC, an RFID reader with antenna and an RFID printer is placed at the information desk.

(ii) *Tagging.* All the books and CD/DVD cases in the library collection would be tagged with RFID labels. This subsystem helps staff to simplify tagging process. In the service desk, a PC and an RFID printer are located.

(iii) *Check-in/Check-out.* This subsystem enables staff in the service desk to perform check-in/check-out operations. A reader with fixed antenna is also placed in the service desk for this operation.

(iv) *Anti-theft Detection.* This subsystem is responsible for theft detection which is a major challenge for libraries. Theft detection pedestal are installed at the entrance/exit gate of the library. Any item that has not been checked-out is detected as it passes through the pedestal. Also, this subsystem detects the person who enters the library without a membership card.

(v) *Inventory Control*. Taking stock at every period is an important function in the libraries with large collections. This subsystem enables staff to perform stock verification quickly. A hand reader can scan hundreds of books/CDs lying on shelves without even a single book being pulled out. This device also helps in sorting shelves and searching for specific items.

(vi) *Administration.* This subsystem enables library manager to maintain check-in/check-out record, stock verification and tagging process information. The subsystem also provides business intelligence reports to the manager.

6. CONCLUSION

Libraries have been seeking technological aids to improve their customer services and management of various services offered [12]. RFID is an automatic identification technology offering potentially a lot more than barcode commonly used in libraries. UHF RFID technology provides for no line of sight identification of items and quick batch scanning therefore less manual operation.

In this study, in order to enhance operational efficiency in a Turkish library, RFID aided library information management system is designed and developed. First, the architectural framework is presented. Then, the main components of the system designed according to the business process analysis are explained.

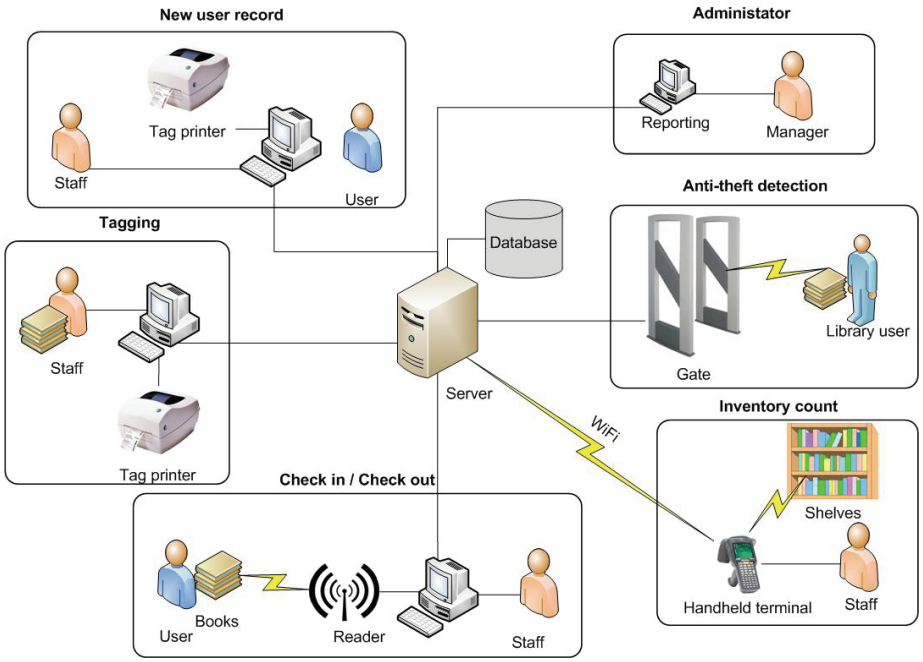

Figure 3. Overview of the RLIS

For the future research; testing, integration and evaluation steps, will be explained. In addition, the benefits and challenges of the development of the RLIS can be examined.

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