Study on Intelligent Library System Based on FRID Technology

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Abstract

As high-tech, radio frequency identification technology has been introduced to the book management, which promotes the overall change of the modern library from service content to service mode, and forms RFID intelligent library. This paper firstly analyzes the background and significance of library management system based on RFID, describes the concept, system components and working principles of RFID in detail, and expounds the application and prospects in the foreign and domestic libraries. On that basis, it proposes the overall structure of intelligent library system, introduces the function and use of each module, fully reflects the automation and intelligent of RFID technology to the library management, sums up the advantages of RFID in the library system, and finally analyzes the reasons and constraints that RFID can not popularized in the university libraries.

Keywords: RFID, Library, Self-Help Borrowing, Electronic Tag, Intelligent Access Control

1. Introduction

RFID is short for Radio Frequency Identification, and it is one of the non-contact automatic identification technologies. The earliest application of RFID can be traced back to World War II, the allied forces used this technology to identify their own aircraft, later it is mainly used on the occasions that bar code is not convenient, and gradually it is used for location, tracking products or other targets. The widely used bar code technology has triggered a revolution in the field of identification systems, but with the development of technology, bar code technology revealed more and more inadequate. At this point, RFID technology came into being and has been accepted great attention and sought.

As RFID technology has many advantages in the identification, such as distance reading, large information capacity, rewritable, small volume, easy operation, integration of identify and security, data encryption, storage and batch read, it has been widely used in retail, logistics management, industrial production, individual records track of green livestock breeding, vehicle security control, authentication, access control, electronic tickets and road automated toll [1]. RFID technology also has a very broad application prospects in the library.

At present, the research of RFID in the library is not enough, and the practical application is not much. As a university library, we should comprehensively and deeply study RFID, know its working principles, relevant properties, application functions and system architecture, so as to do well for the practical application. Based on the research and analysis of RFID application in the university libraries, drawing on the application effectiveness in foreign countries, this article summarizes a variety of RFID systems, so that make more libraries comprehensively know the current status of RFID application, and provide reference for RFID project implementation.

2. Overview of FRID

2.1. System Components

RFID system consists of electronic tags, antenna, reader and host. The tag, non-contact IC card, needs to be set on the identified objects. It is composed of coupling elements and chips, and there are built-in antennas in the tag, which transmits and receives signals. The antenna transmits and receives wireless signals. The reader can send and receive commands, communicate with the host, and execute host command. The host sends user commands and displays received data.
2.1.1. Electronic tag

Electronic tag, also known as smart labels, refers to the ultra-tiny little label composed of the IC chip and wireless communication antenna, whose built-in radio frequency antenna communicated with the reader. When the system works, the reader sends a query signal, the passive label rectifies to DC power to supply circuit within the tag after receiving the query signal, and the other part of the energy signal reflects back to the reader after modulated by the data stored within the electronic tag.

2.1.2. Antenna

The antenna is a device which receives and radiates radio frequency signal power of transceiver in the form of electromagnetic waves. The antenna can be divided into shortwave, ultra short wave and microwave antenna according to work band, and it is divided into Omni directional and directional antennas according to directions.

2.1.3. Reader

The reader is the core of RFID system, the basic role is an exchange link of the core data between forward channel and backward channel. The reader communicates with the application system. The reader modulates and decodes the signal sent by the label, and sent to the application system through USB, serial port and Ethernet port [2]. The application system can send the appropriate commands to the reader and control the reader to complete the task. The reader can activate a number of standard labels within the effective radio frequency range, identify multiple tags at the same time and has anti-collision function.

2.2. Working Principles of RFID

RFID is a non-contact automatic identification technology which uses transmission characteristics of radio frequency signal space coupling to achieve automatic extraction and identification the information by other objects. Inductive coupling refers that it achieves coupling through space high-frequency alternating magnetic field based on transformer model according to the law of electromagnetic induction [3]. Electromagnetic coupling refers that it reflects and brings back the target information after hitting the target through electromagnetic waves based on the radar theory model according to the electromagnetic wave propagation law of space.

RFID system consists of hardware, software basic data format and communication protocol. The hardware is composed of tag, reader and antenna. When the label enters the magnetic field, the reader emits radio frequency signal, the label sends the product information stored in the chip depending on the energy of induced current, or initiatively send a frequency signal, and the reader sends it to the background system for data processing after reading the information and decoding. The composition of FRID system is shown in Figure 1.

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**Figure 1.** Composition of FRID
2.3. Current Application Situation of RFID Technology

The RFID technology has applied in the library already for about 10 years. In the worldwide, more than 2,000 libraries are using RFID technology, and it surges at an annual rate of 30%.

2.3.1. The application of RFID technology in abroad library

Singapore is one of the earliest countries using RFID technology. Every Singapore citizen can borrow books from the National Library with ID card or driver's license [4]. There is an RFID tag on the back of each book, borrowers simply bring the book to the self-help borrowing machine, insert the ID card or driver's license, set the book on the blue panel and the borrowing process is completed. The borrowing machine can also automatically print lists which include the borrowed books, borrowing date and return date. When return the book, the readers can choose any one nearest branch library, just put the book into the machine. The system also has a screen on the top. Using this technology, the readers at the peak waiting time have reduced by 80 percent than before, the lending rate increased by 30 times. In funding, it saves $ 28 million, and in the management, it saves 2000 labor. The lending number increased from 1000 million every year to 3100 million.

Rockefeller University Library began to use the RFID system in 1990, and Farmington Community Library is the first public library in the United States. There had been more than 300 libraries equipped with RFID systems in the United States by 2005, such as the Jefferson National Public Library, San Antonio Library and Minneapolis Public Library. In Asia, in addition to Singapore, Japan, Korea and other countries also apply RFID technology in the libraries [5]. Especially in Japan, they contributed a lot of manpower and material to RFID research and application, RFID technology in the library is in a leading position in the world, and the using number of RFID tags is far more than other countries.

2.3.2. The application of RFID technology in the domestic library

In China, the RFID Smart Collection Management System was completed and put into operation in Cheng Yi College Library of Jimei University, which becomes the first library using RFID technology for smart management. In the same year, Shenzhen Library introduced France TAGSYS RFID implementation scheme, and began to perform self-management for the book circulation. Readers can return books through self-help borrowing machine, and the library staff can accurately track the position of the books on the shelves. In addition, it also implements a series of intelligent automated management features, such as automatic sorting, automatic ordering, self-inventory and radio anti-theft alarm. Then Wuhan Library introduced a full set of equipment of RFID technology, including self-borrow system, intelligent security access control system, bookshelf management system, cataloging system, intelligent library management platform and counter workstation. The system completely changed traditional lending model and collection management services. In addition, the second phase digital library of the National Library, Shanghai Library and Nanjing Library partly implemented RFID technology.

RFID technology uses radio transmission to achieve non-contact identification with the person or things and data exchange. It has many new features that the bar code can not achieve, and it will bring revolutionary changes to the traditional library services if we develop and use the new features. For the application of RFID technology, although it exists many problems, many libraries express that it is not the problem of use or not, but when to use. Therefore, RFID technology has a very broad application prospects in the library.

3. Intelligent Library System Based on FRID

The daily library services usually involve people and materials management, which needs a large number of identification of readers and books, access control, statistics, etc. In the automation time, libraries basically use the bar codes as identify ways to achieve these functions. However, although the bar code is cheap and convenient, it has some inherent disadvantages that are difficult to overcome. For example, because it is easy to wear and tear, it must be attached inside the book, which is inconvenience to use and not entirely suitable for the library. RFID has the functions of bar codes, and on the other hand, there are many new features the bar code can not achieve.
RFID technology is not simply to replace bar codes, but to create new service concepts and business models as a guide, improve service quality and management level from the content and form, and make the modern library be endowed with intelligent meaning based on the digital library. The intelligent library management system based on RFID can manage the location, distribution, circulation and flow of books and objects, enhance the classification, adding code, positioning and data collection, thus greatly improves the efficiency of the library, and the library staff have more time to help readers.

The library system based on RFID provides readers with efficient, seamless library environment regardless of the operating system platform limitations through the integration of RFID technology with library management system. According to the actual use, this article mainly introduces seven parts of the library system, including the label marking system, library cataloging system, the counter service system, the book shelves system, self-circulation system, the reader service system and security access system [6]. The system structure of intelligent library based on FRID technology is shown in Figure 2.

![Figure 2. System structure of intelligent library based on FRID](image)

### 3.1. Labeling

RFID tags in library management system have different uses, so we should provide the use of labels according to the actual need. In general, the label in the system is divided into book labels, shelf labels, layer labels and reader card. Different labels are divided depending on the storage area, but the tag type is the same. The use of tags need to be set by the software, and then packaged into different shapes.

The distribution of labels for various uses in the library is not the same. The book label is attached to the upper left corner of the book back, and the location of each book is roughly the same, so that we can quickly and accurately sort the books when order books. The shelf label is attached to the bottom layer of the shelf, because the reader installed beside the book shelf should read the label when organizes books [7]. The layer label is best affixed near the layer, not close to the other layers, because we should scan the layer label firstly, then scan books, when scan other layer labels, we will change the layer. The reader card has not strict requirements.

### 3.2. Book Catalog

Recently, the publishing has been exploring the ECIP program of Chinese books, and the aim is to automatically extract the metadata for the bibliographic record in the relevant part of typesetting files with computers, generate standardized data format for the whole society, so as to solve repeat catalog problems for data processing. After the books enter the library, the staff directly read out the data stored in RFID tags with readers, the matched computer systems automatically generates business notes of a copy-volume book in batches, and write back to RFID tags, and at the same time, automatically lead the relevant data into the central database of the library [8]. RFID itself has the function of addressing, anti-theft, book mark and bar code, so it maintains maximum degree of original literature. Libraries only need to modify the location, which greatly enhance the consistency and accuracy of cataloging, and save considerable labor costs.
3.3. Counter Service System

This module is done more work, including lending books, returning books, smart label production, book classification and security detection. The borrowing mode is responsible for reading the tag information and setting or removing the security detection bit within the tag, so that the book that has completed the borrowing procedure will not trigger alarm. The librarian can view the label information on the screen, he simply needs to place the books or articles on the identification, and can see the relative information stored in the tag and the security detection bit. The borrowing module can automatically complete the borrowing and returning operation. The table equipment components include RFID tag readers, the matched antenna, bar code readers and manager workstation.

3.4. Sort the Bookshelves

RFID tags can record some important information of books, especially the location information can be written into the label, so we can move from the shelf, collect and collate the books with handheld devices or portable workstation. In the stock inventory model, it collects data in the library, compares with it in the database, and generates the difference report [9]. In the search mode, we can choose specific collections, the data collected by the hand-held scanner will compare with the information stored in the portable workstation. When find the target or misplaced books, the built-in buzzer alarm sounds, and notifies the operating librarian.

For the library, it often happens to put the book in the wrong position, so sorting books becomes especially important. This module is to sort the books after shelf gathering operations and access to location information, get the information of the misplaced books according to the record color in the interface, and then operate on the books following the promotes.

We get the shelf tag information with handheld reader, it shows that we have received the shelf information after hearing the alarm, then scan the RFID tag on the book one by one, and the scanning information appears on the screen, which displays a certain color according to the prompting on the left top corner. The operator can get the information of location and whether in the library or not.

This module provides a simple modification of book information, such as the state error, which shows that the circulation has problems, and feedback to the authorities, and then it can be revised to the correct state.

3.5. Self-help Borrowing Machine

This module is a bright spot of the system. It provides self-help borrow and return for readers, which greatly reduces the burdens for the counter service system. In addition, the return system provides 24-hour uninterrupted work, readers can return books in the low tide of the circulation. All the operations can be done in a self-service borrowing machine.

3.5.1. Self-help borrowing machine

Self-help borrowing machine, also known as automated self-service station, includes simple use instructions. To describe the guiding picture, it can provide language choice and different program operating interface according to needs. When borrow or return books, readers simply need to put the book to the read inductive zone, enter library card number or induction borrowing cards, the device can complete the circulation, including reading book number, ID number of users, updating databases and lift or set the security code in accordance with established procedures [10]. After completing circulation, it can print a list for the user, including the user's identity, borrowing date and return date.

3.5.2. Automatic returning box

It can be placed inside the library, also can be placed in areas outside the library, and provides 24-hour services. It is used for self-return, renewal operation, which is convenient to readers and library staff. Readers can return book at any time. Readers simply need to put the books in the input port, the
device will automatically update the library database remotely, specify the return book and at the same
time set the book RFID security code.

3.5.3. Book classification points

It helps librarians quickly categorize, regulate and insert new books, or find missing books, and also
find an appointment book.

3.6. Reader Services

Reader service system is mainly divided into two ways, one is the library reader service, and the
other is to provide web service of B/S structure. This module can complete the following functions,
query book information, view and modify personal information, renew books, inquiry borrowing
history, registration reader needs and appoint books.

3.7. Intelligent Access Control

The existing anti-theft system book magnetic stripe is low accurate, and the magnetism can easily be
weakened, so the probability of false alarm and missed alarm is great. The security access control can
reduce the book loss rate. RFID not only store the identification information of book materials, but also
contain security information. The tag safety information can be automatically written to the normal
state through normal borrowing. If the reader detects non-borrowing books in the specific exit, it will
provide trigger contacts. When the security door detects the security code, it will remind safety through
access control system and security monitoring systems on line, and RFID system will automatically
alarm [11]. In addition, RFID systems can count the access situation of the relevant personnel in real
time.

4. Implementation of RFID Project in University Libraries

The transformation of RFID system in libraries is a costly, long-term and high-impact project. It is a
complex decision-making process for the library to analyze the feasibility and introduce RFID. The
library should comprehensively analyze the existing industry issues, business process and management
methods, develop appropriate strategies from the aspects of economy, technology, security and culture,
analyze the advantages and problems, and make a secure, flexible, humanized and intelligent library
through decision-making, planning, implementation and evaluation.

4.1. Planning, Tracking, Testing and Demonstration

In the construction process, the first problem the library encountered is the project planning. We
should select professional librarians of high information quality, keep track of the practical application,
widely take in the operation experiences of the first-class operation library in China, learn and research
practical procedures and programs of own library, explore the development law of RFID technology,
and find a correct way for the development of RFID technology. In addition, when plan and design the
application program, the guiding ideology does not overstate the psychological expectations to the
RFID advantages, but reconstruct and optimize the existing business processes, industry issues and
management methods, and make the purpose of improving the overall efficiency realized [12]. For the
security, privacy, standard, integration of the existing system, the label frequency, production function
and suppliers, we should carry out investigation and research deeply.

4.2. Demonstration Projects

As RFID technology is still in the rapid development stage, some technical performance and price
still has much room for improvement. In order to ensure the successful application of RFID systems
and investment saving, we will not pursue implementation and deployment one step. We can priority
use RFID technology in some special collections, such as professional books, audio and video products
and CDs, and study in depth. The results of demonstration projects, such as the rational distribution of the collection, workflow optimization, expanding services and new management model, are all the valuable experiences for the large-scale implementation of RFID in the whole library. In addition to small-scale applications, there should be clear process and plans of the follow-up upgrading and expansion, use the strategy from small to large, from easy to difficult, phased implementation and steady progress, and then expand the use scale until accumulating some experience [13].

4.3. Organize Teams and Enhance Training

Libraries should focus on selection and training high-quality information librarians to participate in the implementation of RFID projects, organize and set up a special team. In the fully support of library leaders, collaboration of the departments of circulation, editorial, technical and office, actively cooperation of suppliers, the library should mobilize all librarians to actively participate in the implementation of RFID technology.

As a new technology comes, many librarians will be unable to adapt, the library should carry out universal pre-service training before project implementation, set out appropriate training programs, conduct management training for the middle managers, technical training for technical staff and operation training for working staff. The library should encourage librarians to participate in various academic conferences, academic exchanges and related lectures and we can also take the form of short-term training and advanced study.

5. Main Advantages of RFID in the Library

Previous book management mainly relies on the bar code, but the bar code is processed singly, easy to wear, can not be changed and can not be reused. The RFID tag can identify a number of labels at the same time, not easy to wear, reusable, and can store large amounts of information. The features make RFID applications in the library have large advantages.

5.1. Simplify Borrowing Process and Improve Circulation Efficiency

University library has large number of books, materials and users, and the circulation time is relatively concentrated. When widely use the bar code as identification, if the readers borrow or return books, the staff must first open the books, find the bar code, and scan the bar code close to it one by one [14]. When use RFID tags, in the process of borrowing books, the staff only need to put RFID readers to the identification range, the electronic tags are activated by the radio frequency, exchange data with the reader, and automatically complete the circulation process. As RFID readers have wide identification range, the staff does not need to scan every book one by one, a large number of books can be scanned once, which improves efficiency, and reduces artificial mal-operation.

5.2. Realize Intelligent Management and Reduce the Workload of Librarians

Most libraries currently adopt the approach of open-shelf borrowing, large circulation and reading, and use the CLC to classify the books as the standard. However, in the open process, some readers are not familiar with the classification rules, and do not place to the original location, so disorder phenomenon frequently occurs. RFID tag has the capacity of storing data, and it can write the shelf and layer information of each book into the chip. When check the shelf marks, the staff uses the handheld RFID readers to scan the book shelves, and he can quickly and accurately find the wrong position.

5.3. Provide Readers with Personalized Service

For early traditional library service, the library staff passively waits for reader, and the readers can not participate in the library [15]. RFID technology carries the reader service forward a big step, and makes the readers really become the main part of libraries. After coming to the library, the readers can quickly find the position of the needed books through RFID searching machine, and directly take the books from the shelf, and borrow on the self-help borrowing machine, which greatly saves the time.
5.4. Improve the Safety of Books

The RFID tag not only includes the information of bar code and magnetic stripe, but also has the anti-theft identification bit that can be rewritten. When readers borrow books, it changes the book status in the library through rewriting the anti-theft identification bit, and the security access control reads and judges whether the books meet the condition. For the books without completing borrowing procedures, the security access control system will give a sound and light alarm, which greatly reduces the stolen behavior and ensures the safety of books.

6. Constrains and Reasons of RFID in the University Libraries

It is not a simple application mechanically for RFID technology to introduce into the library, and it is not tailored for the special needs of the library, so there are many limitations and gaps.

6.1. Technical Standards

There is no official international unified standard for RFID products, so the products of different manufacturers are not compatible, which results in confusion and isolation of RFID products.

RFID technology has been gradually produced three major technical standards, EPC standard in Europe and America, UID standard of Japan and ISO/IEC 18000 standard of the international standard organization. The three standards proposed different basic protocol, and have differences in the wireless bands, anti-collision protocols, data formats and application areas [16].

6.2. Cost

Expensive cost is a major obstacle for RFID to promote in the library. The corresponding equipment and maintenance cost is also quite large [17]. RFID tags have no large-scale production recently, so it is difficult to reduce costs. From the development trend, it is impossible to cut prices sharply in recent years.

6.3. System Integration

The design of existing library management system is based on bar code and magnetic stripe technology, while RFID system is based on RFID smart labels, so the two systems need to integrate in communication protocols and interfaces, and the technology is difficult and costly. If there is no a mature platform and technology, it is difficult to complete the integration of the two systems. These are the reasons why RFID technology is easier accepted in the new library than in the old one, and easier in the small than in the large one.

6.4. Security

Security issues mainly come from two aspects. One is the anti-theft capabilities, RFID tag is attached to the book, it is poor hidden compared with the magnetic stripe, and easily be found and torn. Some libraries use RFID tags and magnetic strip, although solve the problems, the cost and complexity has also increased. It is an important factor for a large scale application of RFID how to improve the ability of RFID tag security, and at the same time take the cost pressures into account. On the other hand it is the reader privacy. RFID tags can easily be intercepted data or tracked, so the intruder is likely to get the reader's borrowing information to know the reader's personal information, borrowing habits and behavior, and even location tracking [18].

7. Conclusions

There is a gap between the current development status of libraries and RFID applications, so the popularization and application of RFID is restricted by many factors. Even if a small number of powerful libraries can achieve RFID in the short term, but for most libraries, the realization of RFID
will require a longer time effort. But it is undeniable that RFID technology can make the library realize real intelligent management. It can provide readers with simple and quick self-service, improve the efficiency of the librarian, save manpower for the library, and provide security environment for readers. The unique advantage of RFID is a technology that other identification technology can be compared. With the rapid applications of RFID in various industries, a significant increase in domestic equipment manufacturers, solution of national standardization problems, the continuous development of new technologies, conception updating of national library and the appropriate increasing funding of library, RFID technology will be increasingly promoted and popularized in the future and drive the construction and development of digital libraries through the common efforts of all aspects.

8. References