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# A Study on the Influence of RFID Tagging on Circulation Services and Collection Management: a Case Study of the Taipei Public Library

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## 1. Introduction

In 1998, the National Library Board Singapore undertook a trial application of RFID (Radio Frequency Identification) on acquisitions, cataloguing, and circulation, and in 2002, it put out the first RFID library management system in the world. The range of applications includes: (Zhou, 2009) checking out and returning books by readers, sorting and delivering books, setting up an automated check-out machine outside library, managing library property, and taking inventories of materials and managing stacks. The management of library property of the National Library Board Singapore is now automated at a high rate of efficiency with its administration making effective use of RFID applications. Inventory work has been simplified resulting in significantly fewer mistakes and manual tasks such as shelving require fewer man-hours. The radio wave sensor also makes it easier to do book searching. Concrete results include: US\$2.8 million can be saved every year; costs for up to 2,000 workers can be eliminated every year; and the number of borrowers can increase to an equivalent of more than 31 million, up from 10 million annually. In addition, many public libraries in the US have begun using RFID. By using RFID, for example, readers can check out and return books by themselves at the San Antonio Public Library. The circulation of library materials has been expedited and made more convenient, the management of stacks is more efficient, the efficiency of librarians has been enhanced, the range of services has been expanded, and the number of patrons has been increasing at a rate of 3% annually over the past few years. For librarians, reading RFID tags by means of hand-held inventory readers makes locating books and confirming the quantity of books much faster. (Zhou, 2009) The RFID automated book sorting system at the Seattle Public Library makes it possible for librarians to serve significantly more patrons in the same amount of time than was previously possible, and the range of services is not limited to clerical duties of checking out and handling returned materials. Even when the library is closed after operating hours, readers can return materials through the return slot outside the library. A conveyor belt then brings the materials to the sorting room, and after the circulation record of the book recorded on a chip is read by the RFID reader, the book will be ready to be shelved. If someone from another branch library has placed a reserve on the book, however,

the book will automatically be sent to a box designated for that branch library. Such material is delivered on the following day ready for the patron who reserved the book to pick it up. Through RFID automated circulation system, the 1.4 million books in the Seattle Public Library System can be returned to shelves automatically, and the 28 branch libraries can obtain requested books in short order. Such an intelligent system has replaced the traditional time- and energy-consuming work of librarians. (Industrial Technology Research Institute, 2009)

Although there are many advantages in using RFID so that it should play a key role in managing library collections, there are some hidden problems that need to be addressed before it can reach the goals of high quality management and meet the demand of actual operations. One of the essential elements in the successful use of RFID in performing library services lies in the quality of RFID tags. Since it is a new service recently launched in the public library systems in Taiwan, potential problems in using it to provide library circulation services may not have surfaced as yet. Thus, one year after the intelligent library management system was set up in the Taipei Public Library, through observation of patrons using the automatic check-out system and gathering their opinions, this study tries to come to grips with related problems to understand the influence of the RFID management system on library patrons and library operation for the reference of all libraries in the effort to enhance service quality and maximize the usefulness of RFID for library services in the future.

## **2. Using RFID in the library**

### **2.1 Introduction**

RFID is a denoting radio detector that uses radio waves to deliver information to identify people or objects carrying encoded microchips. (Chen, 2006) It is comprised of three parts: (Zhuang, 2004)

#### **2.1.1 The RFID tag**

The RFID tag is formed by an antenna, RF Front End, a digital block, and a memory chip. There are usually two types, active and passive, according to whether or not batteries are used. The passive tag receives energy delivered by a reader and transfers the electric energy inside the tag, so no battery is needed. The advantages of a passive tag are its smaller size, cheaper price, and that it is longer lasting.

#### **2.1.2 The reader**

With the delivery of energy and signals by high frequency radio waves, the identification rate of the tag can reach 50 per second. The use of wire line or wireless communication can be combined with its application system.

#### **2.1.3 The application system**

Combined with techniques such as a database management system, the internet, and a firewall, the RFID can provide automatic, safe, and convenient instant surveillance functions.

Presently the RFID standards are commonly used ISO standards, including 1) ISO 14443, commonly used in tickets and cards for public transportation; 2) ISO 15693, used in most

entry cards; and 3) ISO 18000, used in the circulation control of RFID. (RFID Technology Center, 2007)

RFID tags can be divided into three types according to different ranges of radio frequency: 1) 30-300kHz low frequency; 2) 3-30MHz high frequency; and 3) 300MHz-3GHz super-high frequency. Among them, 13.56 MHz is used in many fields, mainly for managing objects, and its advantages include wide-range deployment and imperviousness to moisture; its drawbacks are its limited reading range (within 1.5 meters) and susceptibility to interference by metal objects. (Yu, 2005)

## 2.2 Advantages of using RFID in library collection management over the traditional barcode

The main reason why a library chooses to replace barcodes with the new technique of RFID is that it drastically increases the efficiency of circulation services and inventory operations. Traditionally, the library clerk at a library's circulation desk would need to use a desktop or a handheld sensory barcode reader to read the information on the barcode of each borrowed item. But the RFID technique simplifies the operation of checking out and returning materials mainly because the information of related materials are encoded and stored on RFID tags, and the RF Wireless can transmit information on the tag instead of just reading the traditional barcode in "Line Sight". The system can identify information in a large quantity of built-in chips and the remote cursor can retrieve the information immediately. (Hong, 2005)

Table 1 is differences between barcode functions and RFID functions made by the Information Data Center of the Industrial Technology Research Institute, and it clearly shows the advantages of RFID.

Function	Barcode	RFID
Reading quantity	One barcode is read at a time	Many RFID tags can be read at the same time
Remote reading	Infrared rays are needed to read a barcode	RFID tags can be read or renewed without infrared rays
Information volume	Low volume of information saved	High volume of information saved
Reading and writing capacity	Barcode information cannot be replicated	Electronic information can be read and written repeatedly
Reading convenience	Only barcodes in good condition can be read.	RFID tags can be very thin and can be read even inside packaging.
Information accuracy	Barcodes need to be read by humans, so human errors are possible.	RFID tags can deliver information for tracking materials and for security purposes
Duration	A stained or damaged barcode cannot be read, and have low durability.	RFID tags can be read even when stained or dirty.
High-speed reading	Reading barcodes is more time-consuming.	High-speed reading is possible.

Table 1. Differences between barcode functions and RFID functions

Moreover, after summing up the advantages RFID has over the traditional barcode, RFID can be said to have the following characteristics: (Yiu, 2006; Cheng, 2006)

### **2.2.1 It can access saved information repetitively and it has high storage capacity**

Information in RFID tags can be added, revised, deleted repetitively, and it has many megabytes' storage capacity.

### **2.2.2 It can read information of many individuals at the same time without having to read from a stable angle**

The RFID Reader has a wide range reading capacity than can read many overlapping RFID tags simultaneously and saves time and energy.

### **2.2.3 It reads and identifies information easily and quickly**

The RFID tag is read through a radio frequency which can transmit information even when the tag is not visible.

The above advantages in reading information in RFID tags indeed serve to increase the efficiency of managing materials in an intelligent library and simplify procedural operations of the services offered by librarians at the front line.

## **3. Using RFID in Taiwan's public libraries and related studies**

In Taiwan, besides the Taipei Public Library, the National Taichung Library, the Kaohsiung Public Library, the Xinbei Public Library, and the Library of the Department of Cultural Affairs of Taichung also utilize RFID for their collection management and circulation services. However, limited by the reliability and high costs of RFID, applications of RFID in most of these libraries are limited. The Central Library of Taipei Public Library and its 2 Micro Self-service Libraries use RFID,(Taipei Public Library, 2009) but the other branch libraries continue to use the traditional system. The Xinbei Public Library set up an intelligent library with low-carbon emission at the Banchiao Train Station which uses RFID.(New Taipei City Library, 2010) In Kaohsiung, the Kaohsiung Public Library set up a Micro Self-service Library at an MRT Station. (Kaohsiung Public Library, 2009) All three Micro Self-service Libraries set up by National Taichung Public Library at Taichung Train Station, Taichung Hospital, and China Medical University Hospital each use RFID.(National Taichung Library, 2010)

As many public libraries have some experience using RFID, scholars and graduate students in Taiwan have begun doing research on uses of RFID in libraries and related topics. As for using RFID in libraries, students in the graduate program of Library and Information Science are interested in doing research on this topic; graduate students in technology management, information management, business administration, electronic and information engineering, information communication, applications of information technology, management science, and archival science are also engaged in similar types of research. The main topics include factors for introducing RFID and factors for its successful application, results of introducing RFID, satisfaction of users and acceptance by librarians, as well as the application of RFID in conducting library searches.

Liu Guang-ting explored the service quality, recognition value, and the relationship between using RFID and library patron satisfaction through a questionnaire survey,

mainly to determine whether the source of patron satisfaction was influenced by the use of RFID or not. His research subjects were the patrons of a technical college library and a public library. The results show that using RFID has a positive impact on service quality, recognition value, and patron satisfaction. Liu Guang-ting contended that the results of his research could offer a clear direction for using RFID and can serve as a reference for libraries in their management and choice of system. (Liu, 2008) Moreover, Researcher Tsai Ji-jin chose to undertake a study on the acceptance of RFID by librarians in the libraries of Taiwan (Tsai, 2007)

Pan jing-mei chose to apply TOE (Technology-Organization-Environment) as the framework for her research and collected information on the application of RFID in Taiwan's libraries through a questionnaire to understand the key factors in a library's decision to use RFID. She found that financial readiness greatly influences a library's choice in setting up an RFID system. (Pan, 2008)

Fan Guo-ji explored the procedures required for introducing an RFID system and the results. His research shows that the benefits of using RFID technology in libraries are mainly limited to automated checking out and returning of materials and inventory work. It is especially useful in inventory work as libraries using the system tend to have a much clearer understanding of their collections and can offer accurate information to their patrons. With the automation of library procedures, manpower is replaced by machine-power, and patrons need to fully participate in the procedure of checking out and returning materials. As patrons express satisfaction in the automated procedures for checking out and returning materials, the introduction of RFID technology in libraries is a positive trend. (Fan, 2004 )

Chen Xue-zhu compared the differences between RFID and the present identification management procedure through interviews with librarians and a field survey to understand the operational mode on the management of a featured collection. Another research subject of this study was the Archives of Chinese Information in the World at Shih Hsin University as the application of RFID may differ depending on specific factors of special collections because of differences in surroundings (temperature, moisture, metal shelves), space (controlled entrance, open shelves, closed stacks), and arrangement of materials (new books, categories, target readers). Finally, it examined the application of RFID in related fields and proposed a new management model suitable for special collections. Through in-depth interviews and understanding the advantages and disadvantages of using RFID in libraries, Chen analyzed, sorted, and set up the planning for introducing RFID in the special collections of a library to make it possible to open a special collection to the public, improve its automated management, and promote its service efficiency to library patrons. (Chen, 2007)

Xiung Ya-fei explored "The Key Factors of Successful Introduction of RFID to Library Video and Audio Materials: A Case Study of a Technical College" through the "analytical hierarchy process (AHP)" by coming up with a draft of the framework of the AHP levels in "factors determining the successful introduction of RFID in a library" and designing a questionnaire for experts. She conducted a survey investigation for her study which focused on libraries which successfully introduced RFID and observed the experience and procedures of such introduction. Through observation of individual cases, she obtained more thorough information for the revision of the draft on the framework of AHP levels. She then designed the second questionnaire for experts in her second survey investigation. She compared different aspects at different levels to measure their influence and used the

software “Expert Choice 2000” to calculate the degree of influence of each factor before ranking the factors and determining the “key factors of successful introduction of RFID in the library.” (Xiung, 2010)

This study focuses on individual understanding of the application of RFID in library management and the key factors of its successful introduction. The goal is to identify the most important key factors of the successful introduction of RFID in the library. The result of the study shows that of the five most influential factors of the Level 2 measurement index, “policies of the institution” is ranked number one, ahead of “skills and support system”, “staff of the institution”, “efficiency of the supplier”, and “outside surroundings”. Of the 25 influential factors of the Level 3 measurement index, the top five factors affecting the successful introduction of RFID are: “active participation and support of highly ranked superintendents” (ranked the first), “affordable cost for the institution”, “stability of the system (reading percentage, interference)”, “conformity with the prospects and strategy for development of the institution”, and “effective interaction and communication among staff members of different ranks.” (Xiung, 2010)

Hou Fu-yuan attempted to combine mobile devices and RFID to develop a GIS indoor navigation system as a searching guide for patrons. (Hou, 2008) Zhang Rong-hui combined RFID technology with Wireless LAN for library applications. He designed an information service system to help patrons look for and obtain materials. When a patron inputs the index number of the material he wants into the system, the system locates the shelf containing the material and suggests the most convenient access to the material, so that the patron can find what he or she wants in the least amount of time.

## **4. Intelligent collection management of the Taipei public library**

### **4.1 Setting up intelligent collection management at the Taipei public library**

The Taipei Public Library first evaluated the possibility of applying RFID technology to the management of the library and drew up plans for the direction and the method of application. In 2005, RFID was first applied to collection management under the project “Constructing an intelligent library for the new century.” The first open-book intelligent library to adopt the self-service checkout system was established in Taiwan. In December 2005, the Central Library of the Taipei Public Library System also began using an automated checkout system and changed the original collection management system from barcodes and magnetic strips (See Figure 1) to RFID. Distinct from the traditional checkout system which required a clerical staff, the automated checkout system increases both the speed and the efficiency of checking out materials. In general, the following goals have been achieved through this project:

1. An intelligent library creates a new kind of library service and presents a new image of Taipei as a city of technology, one that promotes reading to its public.
2. The various sites of the intelligent library meet the public’s demands for more libraries and longer service hours.
3. Patrons can enjoy convenient services from information technology and the internet, and they can participate actively to enhance their information literacy.
4. Librarians are able get an instantaneous grasp of the collection status which promotes the efficiency and control of collection management as well as the working efficiency of the library staff.

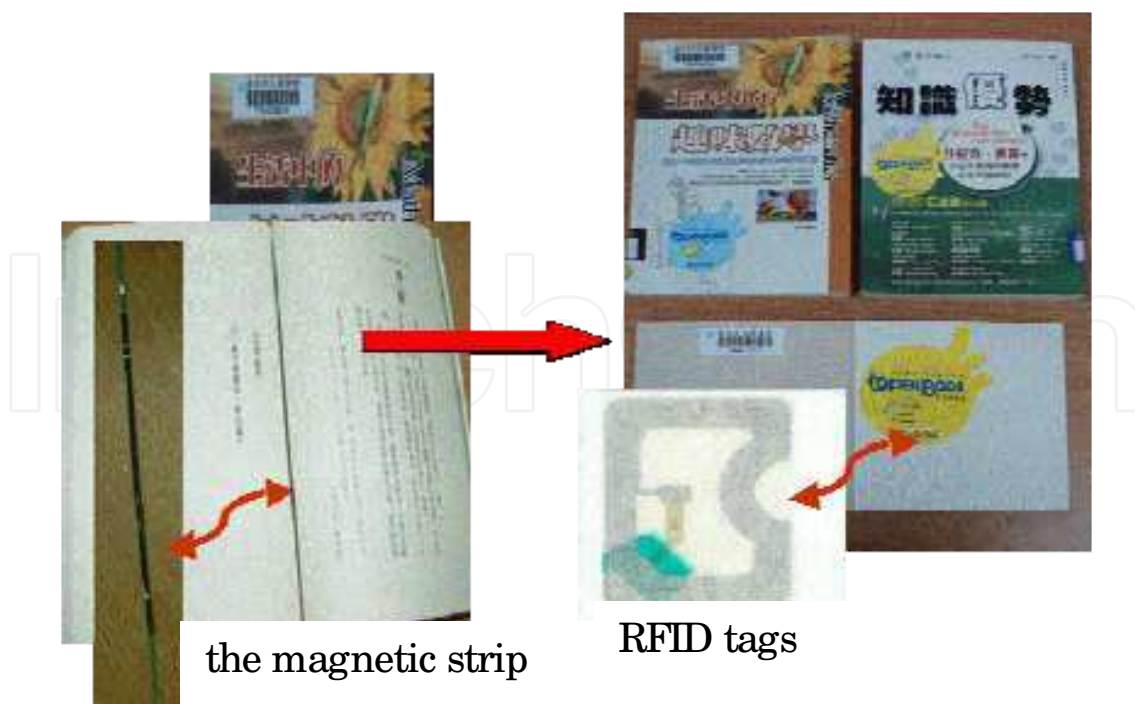


Fig. 1. The change to RFID tags from barcodes and magnetic strips as a control mechanism of the library collection

#### 4.2 Problems stemming from the application of RFID Intelligent collection management

The Taipei Public Library was the first public library to install the RFID automated checkout service in Taiwan. To further understand the influence of this service on how patrons use the library and the functions of librarians, one year after the establishment of the management model of the intelligent library, the Taipei Public Library initiated a study to observe how librarians function at the service desk while eliciting the opinions of patrons and collecting related data for the purpose of improving library services.

After an analysis of the librarians' functions and the patrons' opinions, it was found that the three most popular of patrons' opinions of the intelligent library are:

1. After returning materials to the library through the automated system, records of material checked out are not erased by the system.
2. The sensory system at the entrance emits a signal for unchecked-out materials when the materials checked out through the automated system are carried out at the entrance.
3. Information about checked-out materials of other patrons appears in one's check out record when checking out materials with the RFID tag.

After careful analysis of the above problems, it was concluded that the problems occurred because using RFID for collection management was a new technique and library staff had insufficient experience in dealing with it. The readers' satisfaction affected the persistence of the new service. The following factors also contributed to the occurrence of problems.

The Circulation and Preservation Section of the Taipei Public Library believed that the frequency of the occurrence of these problems when checking out materials was related to the accuracy of wafer processing. When wafer processing was improperly functioned, patrons would not be able to check out materials smoothly, and they would voice



complaints complicating librarians working at the checkout counter. In order to raise the service quality, decrease problems at the checkout counter, and provide patron satisfaction, a standard operating procedure was set up not only as a basis for librarians, but also as a reference for other libraries when changing to an RFID collection management in the future. The staff members who worked in the Circulation and Preservation Section in Taipei Public Library formed a quality-control circle to explore the relationship between the problems occurring during checking out through the automated system and the use of RFID tags under the title “Decreasing the frequency of improper wafer processing of the RFID collection management”. They also applied the method of “problem solving” in their quality-control management approach to conduct the status investigation, draw up improvement policies, and practice the policy operation mechanism of the P-D-C-A pattern. Then they reviewed the outcome as a reference to improve the collection management quality of the intelligent library.

## 5. Analysis of problems occurring when using RFID tags at the Taipei public library

To make sure that the efficiency of RFID tags is the main factor affecting the quality of collection management of intelligent libraries, the staff of the Quality Control Circle of the Taipei Public Library analyzed the main factors of the above problems with a fishbone diagram (Fig. 2) and proposed several policies to address these problems:

Decrease the frequency rate of the security alarm at the entrance to 3%; the alarm is activated when patrons take out materials by mistake.

Improve the quality of operations and decrease the frequency rate of processing mistakes of RFID tags to 0.5%.

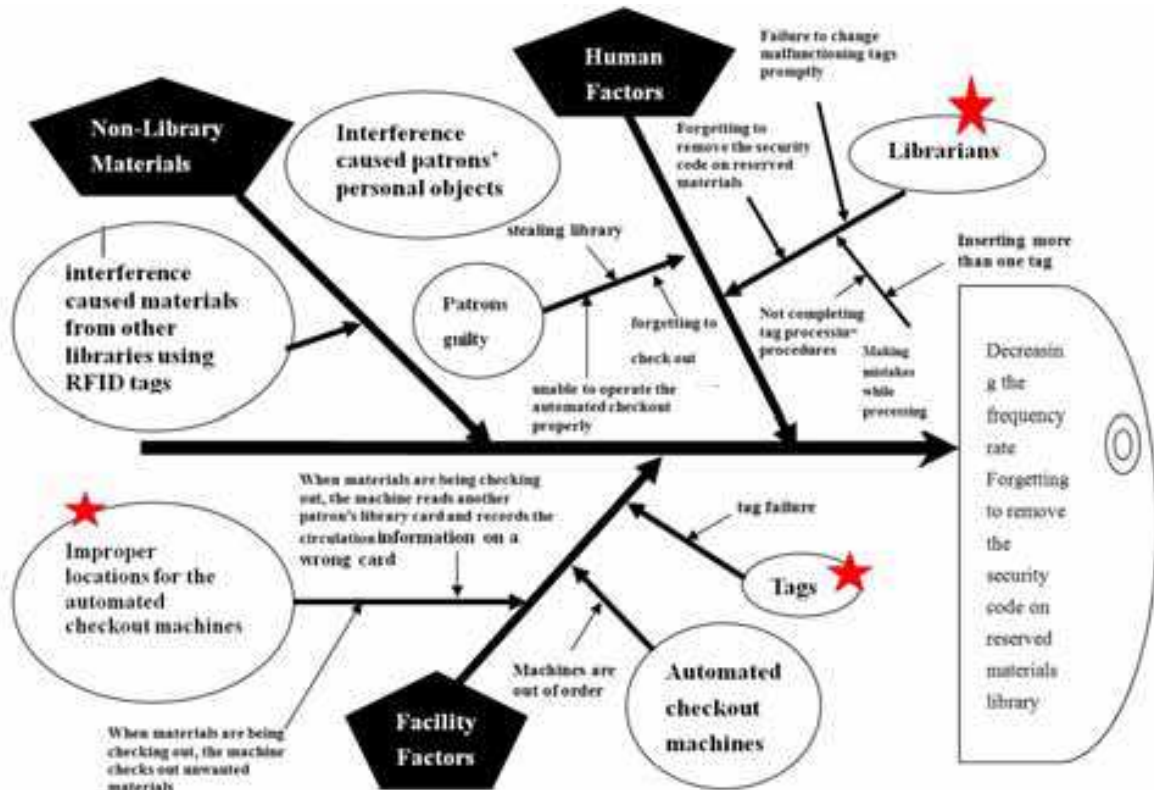


Fig. 2. Analysis of Main Factors (a fishbone diagram)

### 5.1 Policies for promoting the efficiency of RFID tags

In the analysis shown in the fishbone diagram in Figure 2, three possible factors causing the malfunction of an RFID tag are indicated--human factors, facility factors, and problems caused by outside library materials. The analysis explores possible problems in these factors. Human factors stem from both patrons and librarians; the facility factors include problematic tags and the automated checkout machines, and poor location the machines; the third set of factors include personal objects and materials with RFID tags carried into the library by patrons. The Taipei Public Library proposed improvement strategies to address these three factors: 1) the improper placement of automated checkout machines, 2) processing mistakes made by librarians, and 3) the improper operation of automated checkout machines. The staff of the Quality Control Circle of the Taipei Public Library investigated possible ways of improving the above three factors which are described below:

#### 5.1.1 Improper location of automated checkout machines

##### 5.1.1.1 Description of the problem

The three automated checkout machines are located at the service desk on the first floor of the Central Library of the Taipei Public Library. As the RFID's sensory zone of RFID can read material 30 cm. away, many mistakes occur when a crowd of patrons line up to check materials out.

##### 5.1.1.2 Suggested improvement

After discussion, the staff of the Quality Control Circle of the Taipei Public Library found locations for the automated checkout machines to enlarge the service area for patrons checking out material, thereby decreasing reading errors made by the machine.

##### 5.1.1.3 Results

After repositioning the automated checkout machines, the frequency rate of mistakes occurring when materials are checked out decreased to 1.9% from the previous 5.1 % (Fig. 3), much more efficient than the anticipated 3%.

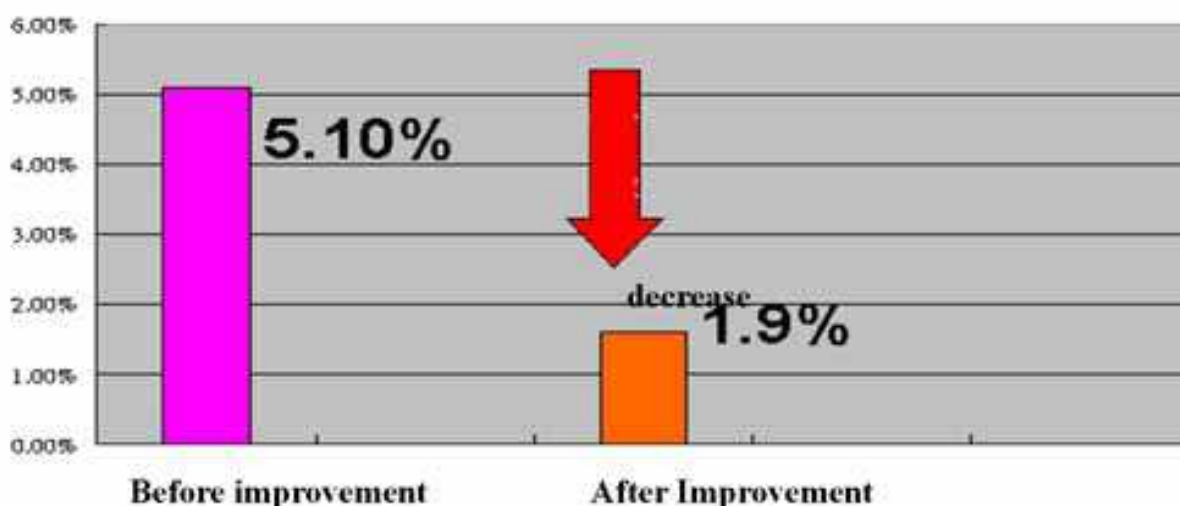


Fig. 3. Frequency Rate of the security alarm at the entrance activated due to patrons taking out materials by mistake

## 5.1.2 Processing mistakes made by librarians

### 5.1.2.1 Description of the problem

Librarians made mistakes when processing the RFID tags, so the RFID security code could not be removed.

### 5.1.2.2 Suggested improvement

After discussion, the staff of the Quality Control Circle of the Taipei Public Library proposed the following strategies:

1. Collect all the material with problematic RFID tags and identify the problems of these RFID tags.
2. Set up standard procedures for wafer processing and checking out requested materials
3. Revise the processing program of RFID tags in the Central Library and the intelligent libraries.
4. Review the regulations for the procurement of RFID tags.

### 5.1.2.3 Results

The staff of the Quality Control Department of the Taipei Public Library categorized the problems of RFID tags into three types: faulty tags, tags torn off, and 2 tags mistakenly put on one item by a librarian. After a standardized procedure was set up, problems concerning faulty RFID tags can now be tracked and controlled regularly. The situation in which patrons were unable to check out materials because of tag problems has been greatly improved. Fig. 4 and Fig. 5 show that the percentage of materials with problems has decreased to 0.62% from 4.02%. But it has not reached the expected 0.5 % because the RFID tags currently used come from the original procurement supply.

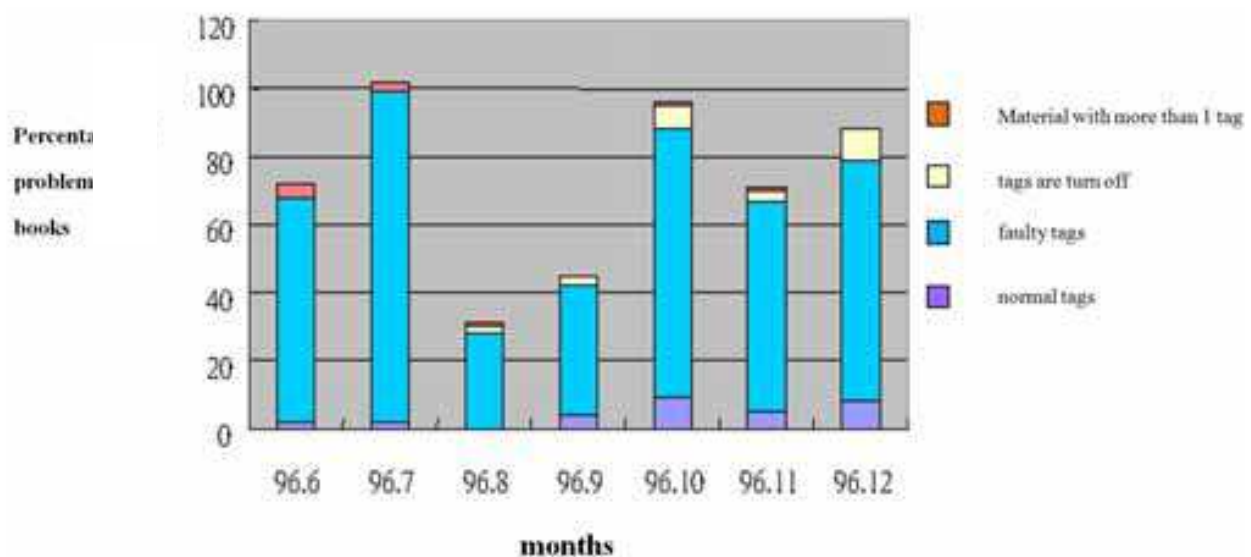


Fig. 4. Percentage of different types of problematic materials in different months

## 5.1.3 Improper operation of automated checkout machines

### 5.1.3.1 Description of the problem

Since patrons tend to be unfamiliar with the automated checkout machines, when they try to check out materials, they are unable to remove the security code of the RFID tags.

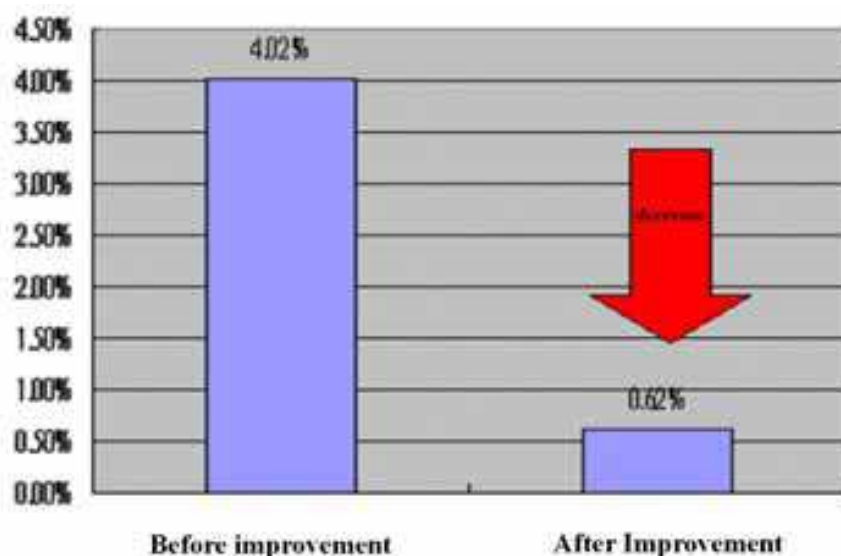


Fig. 5. Percentage of problems due to processing mistakes

**5.1.3.2 Suggested improvement:**

1. Clarify the instructions for operating the automated checkout machines. Place simple and clear illustrations of step-by-step procedures for patrons who have never used such machines to learn how to operate it in a short time.
2. Assign volunteer workers to help patrons operate the machines.

**5.1.3.3 Results**

The use of clear illustrations and the help of volunteer workers increased the efficiency of patrons' use of the automated check-out machines and diminished problems due to misreading.

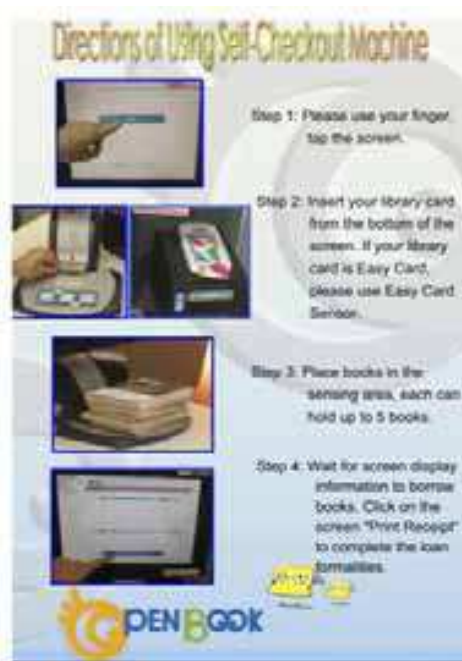


Fig. 6. Step-by-step illustrations for operating the automated check-out machine

### **5.1.4 Reasons of decreasing mistakes during process RFID**

One policy proposed to eliminate mistakes during the processing of RFID tags was to enhance the standardized processing and revise the original wafer processing program. The statistics collected after the policy was put into effect show a decrease in the number of patrons unable to exit the library due to mistakes made during processing RFID tags. The reasons are analyzed below:

#### **5.1.4.1 Standardizing operating procedures:**

The Department of Reading of the Public Library produced a flow chart of the RFID wafer processing procedure for new staff and staff members liable to make mistakes during processing due to their unfamiliarity with the procedure. In addition, the supplier was requested to revise the wafer processing program so that librarian only had to choose the library for processing on the computer screen instead of having to revise the program code, thereby simplifying the processing procedure.

#### **5.1.4.2 Reviewing and reproducing information on RFID tags:**

Specific librarians were put in charge of the wafer processing procedure for placing RFID tags on problematic materials and new materials, so that faulty tags would be eliminated to ensure circulated materials could pass through similar security mechanisms.

#### **5.1.4.3 Establishing procurement specifications of RFID tags for quality control:**

A statistical analysis indicated that faulty tags made up the highest percentage of problematic tags. Therefore, starting from 2008, the procurement contract stipulated that suppliers are required to attach a certificate of inspection of RFID tags, and an increased number of tags will be tested upon delivery to decrease the number of defective products. Other terms listed on the contract include:

1. Tags need to meet the standard of ISO 15693 at the frequency rate of 13.56MHz.
2. The base of the tag and the antenna must be strengthened, and antenna is to be made of copper wire.
3. When bidding, the defective tags should not make up more than 5 % of the procured order.
4. Authorization by a certified notary public is required and the warranty period should be clearly listed.

## **5.2 Actual results**

After going over the above policies, analyzing the important factors, setting up policies for improvement, confirming the results, and setting up standard procedures, the actual results are as follows:

1. The quality control circle staff proposed improvement policies leading to the following results
2. a decline in the frequency rate of mistakes occurring when patrons check out materials through automated machines to 1.9%.
3. a decrease in the rate of defective tags to 0.62%, leading to improvements in processing.
4. After the staff of quality control circle proposed and implemented new policies, patrons have voiced fewer complaints about problems when checking out materials using the automated checkout, improving the quality of circulation services.
5. The establishment of a standard operating procedure for processing RFID tags decreased the frequency rate of errors occurring during processing.

6. Quality testing of the RFID tags at the procurement stage and a quality control operation were set up.
7. Improvements made to the checking out system to facilitate patrons in checking out material led to increased efficiency and quality.

### **5.3 Future application**

Managing the library collection with RFID technology shows the advantages of RFID. The results of further analysis and improvements made to related operations in the Taipei Public Library indicate that RFID technology can also be applied to the following:

1. As the experience of this project is shared and passed on, any branch library or reading room of the Taipei Public Library can apply RFID technology.
2. It can serve as a model for solving problems concerning RFID tags for other libraries.
3. Standardizing the specification of RFID tags and testing mechanisms can be used as references for other libraries at the time of procurement.
4. The Taipei Public Library can serve as a consultant for the application of RFID and related operations in other public libraries in Taiwan. The RFID management system of an intelligent library is a good model for others.

## **6. Future direction for the quality improvement of RFID tags**

Even though RFID tags have many advantages and have become more broadly applied in managing library collections, problems still exist in the application of this technology. Only when these problems are resolved will this technology be successfully used in actual operations and eventually reach the goal of high quality management. The following is a summary of the problems that the Taipei Public Library encountered in practice and possible directions for improvement in the future:

### **6.1 The types of materials used for book covers and the edition shape of books affect the reading rate of RFID tags**

Presently, publishers are striving for novel and diversified designs for publications, so that covers and edition types of books are well diversified. Metal or shiny book covers (Fig. 7 and 8) are not rare, and the shapes of books are often irregular. These affects the way libraries manage their collections with the application of RFID.

RFID transmits signals through electromagnetic waves, so it is extremely sensitive to liquids and metals. Book covers containing metal lower the success rate of RFID tag reading. Though some SMDs can counter the effect of metals, they are more expensive than the RFID tags themselves, so this solution is not cost-effective. (Zhang, 2006)

In the future, if the research and develop unit or the supplier of RFID tags can develop a less expensive product and solve the problem of metal interference in reading RFID tags, then metal-laced book covers can be read effectively, and ensure the implementation of a comprehensive automated checkout service.

### **6.2 The position of the RFID tag on a book affects the efficiency of inventory operations**

Let us take the processing of the RFID tags in the Taipei Public Library as an example. Poor reading habits of certain patrons tend to ruin the wiring in the tag and the fixed position of RFID tags in books may affect the ability to read tags when books are stacked in piles. Most tags are pasted on book covers or on the inside of book covers.

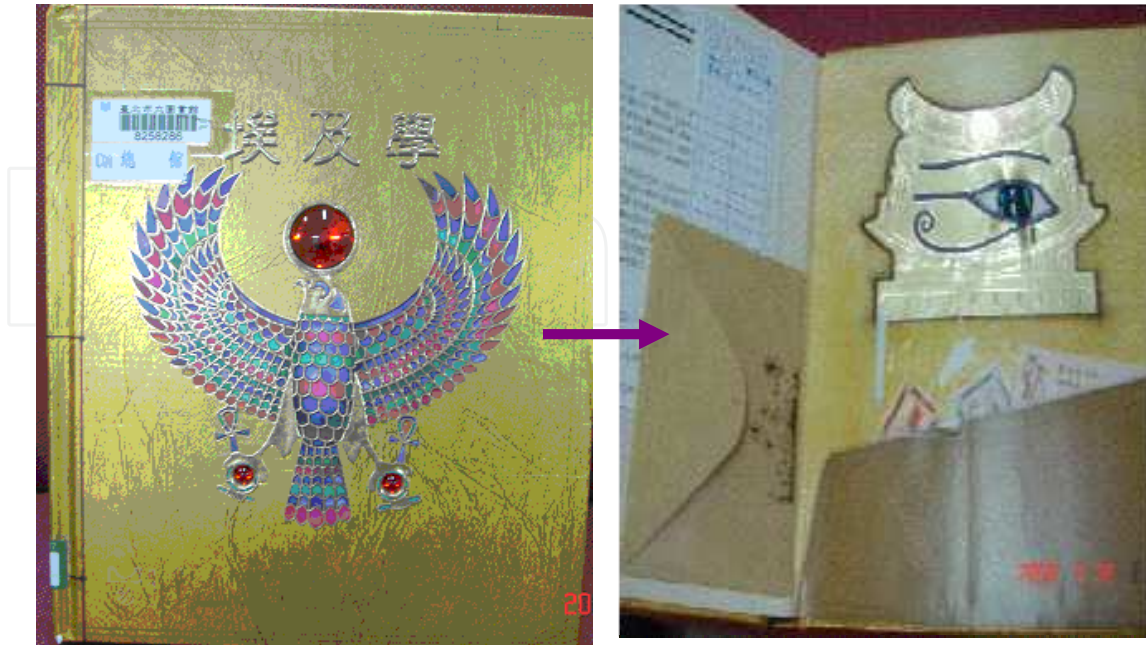


Fig. 7. A book cover and text containing metal



Fig. 8. A book cover with reflective material

Usually the spine of the book is shelved facing outward; thus originally RFID tags were located in the inner part of shelves. The use of a racket-like portable reader, which is bigger and heavier, lowers the efficiency of librarians. Moreover, the reading range of a portable reader is unstable. Most libraries that have adopted RFID technology to manage their collections keep the bar code system and do not have the advantage of comprehensive RFID wireless reading. For example, the Taipei Public Library has not replaced all of its bar code label applicators with RFID label applicators, so the managing collections still has room for improvement.

If the function of RFID portable readers can be strengthened in the future and the hardness of the wiring and micro-circuitry in the RFID tag can be improved, the attrition rate can be effectively decreased. RFID tags suitable for publication can be developed and processing can be improved, making the application of RFID technology in the library more extensive and practical.

### **6.3 The size of RFID tags affects its widespread use**

As mentioned earlier, with respect to the security mechanism of books, the relatively large size of RFID tags makes them more difficult to hide than the original bar codes. So the tags are more fragile. This increases not only the number of problems in checking out library materials by means of automated checkout machines, but also the frequency of replacing RFID tags.

Mr. Ogawa, the director of the Municipal Central Library in Yokohama, Japan, showed the RFID tags that his library used when he participated in the “International Conference on Operation Management and Service Trends of the Public Library” held by the Taipei City Library for its 55<sup>th</sup> anniversary. The shape and the size of the RFID tag is similar to the present bar code. Conforming to the management needs of the library, the library had RFID tags produced as a bar code and pasted the tag on the spine of a book, just like the existing magnetic strip, so that the tag would not be easily damaged and could be used for a longer period of time. However, the tag’s super high frequency 300MHz-3GHz cannot be used in Taiwan which does not apply tag readers of such frequency.

In the future, if suppliers in Taiwan can develop a more compact RFID tag that conforms to the existing ISO standard and reading frequency and is easier to hide, this will solve the difficulties RFID tags encounter in library applications and make them more widely accepted and useful in a broader range of library services.

### **6.4 Data link of RFID tags and automated circulation system for shelved material**

RFID technology can be applied in the circulation of materials. When materials are to be stored, staff members can decide where they should be put according to their suppliers, time of procurement, and user demand, so that materials procured first can be used first, and due dates can be controlled. When the materials are delivered to the processing unit, they are listed and catalogued by means of RFID. This assures accurate processing and avoids mistakes and misplacement of materials, making the material available to the public in a much shorter period of time. (RFID Flow and Supply Chain Resource Center, Chang Gang University, 2009)

The library may adopt the same mode of purchasing and processing to establish a complete management mechanism of books and shelving. When new material is placed on shelves in the library, librarians can determine their location in the library from a distance through the



application of RFID, review how often an item has been checked out to determine how valuable the material is and if it is no longer being used. Patrons can easily learn about the circulation status of materials by checking on the computer adjacent to the shelving area, making it easy to find exactly what he or she wants. This is indeed the way intelligent collection management should work.

## 7. Conclusion

The rapid increase in the quantity and quality of information technology has transformed the fields of information science, mass communications, and broadcasting, as well as the way people obtain information and knowledge. The growth of information proceeds exponentially. The public needs to be able to acquire increasing amounts of information and develop information literacy. In order to meet the public's needs and demands, the library offers convenient access to information; consequently, it has to keep pace with developments in the field of high technology, and offer services that transcend traditional services. Applications of modern technology help libraries transcend the limitations of time and space and to improve the quality and efficiency of the services they provide.

Among new technologies, standard regulations have been gradually set up for RFID system beginning in 2001.(Zhuang, 2004) With its automated identification recognition, RFID has been ranked as one of the ten most important inventions of the 21<sup>st</sup> century and is an important tool in the future of industrial development throughout the world. (RFID Technology Center, 2009) RFID has drawn attention from scholars in a wide range of fields, and with its rapid development, it will soon be used in a manifold number of ways in widely different areas.

Presently, the application of RFID in libraries is still relatively new, so in most cases libraries have only made partial use of it. How to increase its stability, and control its quality, to increase the good will of library staff in adopting this new technology, and to lower its unit price are key factors in transforming circulation services and replacing the entire system of traditional bar codes and magnetic strips with RFID technology.

The staff of the Circulation and Preservation Section of the Taipei Public Library set up the Quality Control Circle for the purpose of identifying problems arising with the use of RFID. It analyzed the reasons by means of a fishbone diagram, and proposed several solutions to improve circulation operations and decrease the number of patron complaints. Their experience in dealing with problems stemming from the use of RFID and propose ways to improve its performance can serve as an important reference for other public libraries in Taiwan that have begun using RFID technology.

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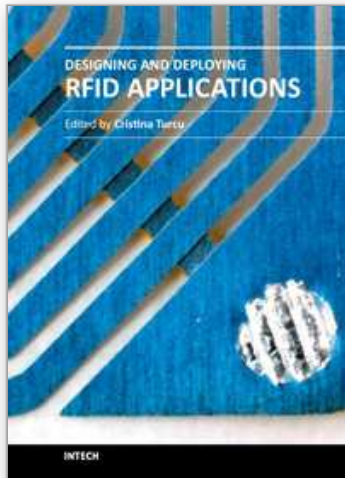
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## **Designing and Deploying RFID Applications**

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Radio Frequency Identification (RFID), a method of remotely storing and receiving data using devices called RFID tags, brings many real business benefits to today world's organizations. Over the years, RFID research has resulted in many concrete achievements and also contributed to the creation of communities that bring scientists and engineers together with users. This book includes valuable research studies of the experienced scientists in the field of RFID, including most recent developments. The book offers new insights, solutions and ideas for the design of efficient RFID architectures and applications. While not pretending to be comprehensive, its wide coverage may be appropriate not only for RFID novices, but also for engineers, researchers, industry personnel, and all possible candidates to produce new and valuable results in RFID domain.

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