RFID APPLICATIONS IN LIBRARIES

A. K. Varma M Imtiaz Ahmed

Abstract

RFID (Radio Frequency Identification) allows an item, for example a library book, to be tracked and communicated with by radio waves. This technology is similar in concept to a cell phone. RFID is a broad term for technologies that use radio waves to automatically identify people or objects. There are several methods of identification, but the most common is to store a serial number that identifies a person or object, and perhaps other information, on a microchip that is attached to an antenna (the chip and the antenna together are called an RFID transponder or an RFID tag). The antenna enables the chip to transmit the identification information to a reader. The reader converts the radio waves reflected back from the RFID tag into digital information that can then be passed on to computers that can make use of it

1. Introduction

Radio Frequency Identification (RFID) is an automatic identification method, relying on storing and remotely retrieving data using devices called RFID tags or transponders. An RFID tag is a small object that can be attached to or incorporated into a product, animal, or person. RFID tags contain silicon chips and antennas to enable them to receive and respond to radio-frequency queries from an RFID transceiver. Passive tags require no internal power source, whereas active tags require a power source. [4]

RFID (Radio Frequency Identification) is a type of automatic identification and tracking system, but to add a difference, it is a system which has the potential to track a product or a person, its entire life cycle, without any physical intervention.

An RFID system may consist of several components: tags, tag readers, edge servers, middleware, and application software.

The purpose of an RFID system is to enable data to be transmitted by a mobile device, called a tag, which is read by an RFID reader and processed according to the needs of a particular application. The data transmitted by the tag may provide identification or location information, or specifics about the product tagged, such as price, color, date of purchase, etc. The use of RFID in tracking and access applications first appeared during the 1980s. RFID quickly gained attention because of its ability to track moving objects. As the technology is refined, more pervasive and possibly invasive uses for RFID tags are in the works.

In a typical RFID system, individual objects are equipped with a small, inexpensive tag. The tag contains a transponder with a digital memory chip that is given a unique electronic product code. The interrogator, an antenna packaged with a transceiver and decoder, emits a signal activating the RFID tag so it can read and write data to it. When an RFID tag passes through the electromagnetic zone, it detects the reader's activation signal. The reader decodes the data encoded in the tag's integrated circuit (silicon chip) and the data is passed to the host computer. The application software on the host processes the data, often employing Physical Markup Language (PML).

Take the example of books in a library. Security gates can detect whether or not a book has been properly checked out of the library. When users return items, the security bit is re-set and the item record in the Integrated Library System is automatically updated. In some RFID solutions a return receipt can be generated. At this point, materials can be roughly sorted into bins by the return equipment. Inventory wands provide a finer detail of sorting. This tool can be used to put books into shelf-ready order.

2. Working of RFID

Some facts about RFID:

- Provides wireless link between products, management information system and consumable transponder consists of an IC and an antenna.
- It involves use of tags or transponders which collects data and manages it in changeable or portable database.
- Unlike BARCODE, RFIDs can identify and track the products.
- Does not need contact or line-of-sight as information exchanged is done through radio waves.
- RFID tags can withstand harsh and rugged environment.
- According to Wake Inc., it can store information up to 32 MB (tag id :I-Q32T w/ LED) which can be changed of updated.

The RFID tags can be of the following frequencies :

Frequency Classification	Band	Reading Range
Low Frequency	125 KHz	0.3 Meters
High Frequency	13.56 MHz	1 Meters
Ultra High Freq.	433 MHz to 2.45 GHz	1-3 Meters
Microwave Freq.	2.45 GHz to 300 GHz	2+ Meters

The RFID tags are of the following types :

A. **Passive RFID** tags have no internal power supply.

B. **Semi-passive RFID** tags are very similar to passive tags except for the addition of a small battery.

C. **Active RFID** tags or *beacons*, on the other hand, have an their own internal power source which is used to power any ICs and generate the outgoing signal.

3. Use of RFID in Libraries

As stated above in Section 2 that the ‘Passive RFID’ tags don’t need any external power supply, hence this property of them, makes them an ideal candidate for use in the libraries for keeping track of the most prized things – the books.

The RFID labels enable the members to pass by card readers that automatically update the computer system, indicating that the book has been checked out. The ID information on the patron’s library card is synchronized with the book, enabling accurate recordkeeping.

3.1 RFID Usage

RFID can be used in library circulation operations and theft detection systems. RFID-based systems move beyond security to become tracking systems that combine security with more efficient tracking of materials throughout the library, including easier and faster charge and discharge, inventorying, and materials handling (Boss 2004).

This technology helps librarians reduce valuable staff time spent scanning barcodes while charging and discharging items. RFID is a combination of radio -frequency-based technology and microchip technology. The information contained on microchips in the tags affixed to library materials is read using radio frequency technology, regardless of item orientation or alignment (i.e., the technology does not require line-of-sight or a fixed plane to read tags as do traditional theft detection systems). The RFID gates at the library exit(s) can be as wide as four feet because the tags can be read at a distance of up to two feet by each of two parallel exit gate sensors.

3.2 Components of an RFID System

A comprehensive RFID system has four components:

1. RFID tags that are electronically programmed with unique information
2. Readers or sensors to query the tags
3. Antenna
4. Server on which the software that interfaces with the integrated library software is loaded.

Tags

The heart of the system is the RFID tag, which can be fixed inside a book's back cover or directly onto CDs and videos. This tag is equipped with a programmable chip and an antenna. Each paper-thin tag contains an engraved antenna and a microchip with a capacity of at least 64 bits. There are three types of tags: "read only", "WORM," and "read/write" (Boss 2003). "Tags are "read only" if the identification is encoded at the time of manufacture and not rewritable."WORM" (Write-Once-Read-Many) tags are programmed by the using organization, but without the ability to rewrite them later. "Read/write tags," which are chosen by most libraries, can have information changed or added. In libraries that use RFID, it is common to have part of the read/write tag secured against rewriting, e.g., the identification number of the item.

Readers

RFID readers or receivers are composed of a radio frequency module, a control unit and an antenna to interrogate electronic tags via radio frequency (RF) communication (Sarma et al. 2002). The reader powers an antenna to generate an RF field. When a tag passes through the field, the information stored on the chip in the tag is interpreted by the reader and sent to the server, which, in turn, communicates with the integrated library system when the RFID system is interfaced with it (Boss 2004).

RFID exit gate sensors (readers) at exits are basically of two types. First type reads the information on the tag(s) going by and communicates that information to a server. The server, after checking the circulation database, turns on an alarm if the material is not properly checked out. Another type relies on a "theft" byte in the tag that is turned on or off to show that the item has been charged or not, making it unnecessary to communicate with the circulation database.

Readers in RFID library are used in the following ways (Boss 2003):

- Conversion station: where library data is written to the tag
- Staff workstation at circulation: used to charge and discharge library materials
- Self check-out station: used to check out library materials without staff assistance
- Self check-in station: used to check in library materials without staff assistance
- Exit sensors: to verify that all material leaving the library has been checked out
- Book-drop reader: used to automatically discharge library materials and reactivate security
- Sorter and conveyor: automated system for returning material to proper area of library
- Hand-held reader: used for inventorying and verifying that material is shelved correctly.

Antenna

The antenna produces radio signals to activate the tag and read and write data to it. Antennas are the channels between the tag and the reader, which controls the system's data acquisitions and communication. The electromagnetic field produced by an antenna can be constantly present when multiple tags are expected continually. Antennas can be built into a doorframe to receive tag data from person's things passing through the door.

Server

The server is the heart of some comprehensive RFID systems. It is the communications gateway among the various components (Boss, 2004). It receives the information from one or more of the readers and exchanges information with the circulation database. Its software includes the SIP/SIP2 (Session Initiation Protocol), APIs (Applications Programming Interface) NCIP (National Circulation Interchange Protocol) or SLNP necessary to interface it with the integrated library software but no library vendor has yet fully implemented NCIP approved by NISO (Koppel, 2004). The server typically includes a transaction database so that reports can be produced.

Optional Components

Optional RFID system includes the following three components (Bibliotheca 2003):

1. RFID Label Printer
2. Handheld Reader
3. External Book Return
4. RFID label Printer

An RFID printer is used to print the labels with an individual barcode, library logo, etc. When the print is applied, it simultaneously programs the data in to the chip. After this process, the RFID label is taken from the printer and applied to the book.

Handheld Reader/Inventory Wand

The portable handheld reader or inventory wand can be moved along the items on the shelves without touching them. The data goes to a storage unit, which can be downloaded at a server later on, or it can go to a unit, which will transmit it to the server using wireless technology. The inventory wand will cover three requirements:

- Screen the complete book collection on the shelves for inventory control
- Search for books, which are misshelved
- Search for individual book requested.

Other applications can be written for the inventory wand, since the system utilizes a personal data terminal (PDT).

3.3 Help of RFID to Libraries

3.3.1 Key Features of RFID in Libraries

The reliability of the system, its ease of operation, and the flexibility of tagging all kinds of media easily, are important criteria in choosing an RFID system. The main aim for today's libraries in adopting RFID is the need to increase efficiency and reduce cost. Automation and self-service can help libraries of all sizes achieve these aims, and RFID has the added advantage that it can also provide security for the range of different media offered in libraries. The technology can also improve circulation and inventory control, which helps allocate human and financial resources. This means that libraries can relieve their professional employees of routine work and operational tasks.

All of the tags used in RFID technology for libraries are "passive." The power to read the tags comes from the reader or exit sensor (reader), rather than from a battery within the tag. A few libraries use "smart" card, which is an RFID card with additional encryption, is an alternative to merely adding an RFID tag on staff and user identification cards (Boss 2004). Not only does that identify users for issue and return of library materials, but also for access to restricted areas or services. This would make it possible to make it into a "debit" card, with value added upon pre-payment to the library and value subtracted when a user used a photocopier, printer, or other fee-based device, or wished to pay fines or fees.

3.3.2 Self-charging/Discharging

The use of RFID reduces the amount of time required to perform circulation operations. This technology helps librarians eliminate valuable staff time spent scanning barcodes while checking out and checking in borrowed items. For the users, RFID speeds up the borrowing and return procedures. Library employees are released for more productive and interesting duties. Staff is relieved further when readers are installed in book drops.

3.3.3 Reliability

The readers are highly reliable. Several vendors of RFID library systems claim an almost 100 percent detection rate using RFID tags (Boss 2004). Some RFID systems have an interface between the exit sensors and the circulation software to identify the items moving out of the library. Were a library user to leave the library and not be caught, the library would at least know what had been stolen. If the user card also has an RFID tag, the library will also be able to determine who removed the items without properly charging them.

Other RFID systems encode the circulation status on the RFID tag. This is done by designating a bit as the "theft" bit and turning it off at time of charge and on at time of discharge. If the material that has not been properly charged is taken past the exit gate sensors, an immediate alarm is triggered. Another option is to use both the "theft" bit and the online interface to an integrated library system, the first to signal an immediate alarm and the second to identify what has been taken out.

3.3.4 High-Speed Inventorying

A unique advantage of RFID systems is their ability to scan books on the shelves without tipping them out or removing them. A hand-held inventory reader can be moved rapidly across a shelf of books to read all of the unique identification information. Using wireless technology, it is possible not only to update the inventory, but also to identify items, which are out of proper order.

3.3.5 Automated Materials Handling

Another advantage of RFID technology is automated materials handling. This includes conveyor and sorting systems that can move library materials and sort them by category into separate bins or onto separate carts. This significantly reduces the amount of staff time required to ready materials for re-shelving.

3.3.6 External Book Return

Libraries can offer a distinct service that is very useful for users, such as the ability to return books when the library is closed. An external book return is a machine with a slot with a chip RFID reader integrated into the wall. It works the same way as the self checkout station. The user identifies himself/herself (if required by the library), and then puts the book(s) in to the slot. Upon completing the return, the user will receive a receipt showing how many and which books were returned. Since they have already been checked in, they can go directly back onto the shelves. These units can also be used with sorter and conveyor systems.

4. Challenges Faced

4.1 Lack of World wide standards

The concern here is the possibility of a standardized RFID communication system as each country owns and controls its own radio spectrum. Manufacturers of RFID systems have also avoided creation of standards, as their focus was development of competing products. Thus a reader produced by company X cannot understand the radio transmission of a tag produced by company Y.

4.2 Tag /Reader Collision

Since there is a possibility of multiple tags getting energized simultaneously, collisions may occur in transmission. Tag collision occurs when more than one chip reflects back a signal at the same time, thereby confusing the reader. Another type of collision that may occur in RFID is termed as the reader collision. In this, signal from one reader interferes with the signal from another where coverage overlaps. Therefore good anti-collision protocol that will facilitate simultaneous reading of tags, providing a quick and precise read, is necessary.

4.3 Expensive

RFID implementation demands huge investments at both manufacturer and retailer ends. The new tag production techniques adopted by some companies may lighten the burden to some extent at the manufacturer end.

4.4 Loss of Privacy

Even though the technology is gathering wide attention at the manufacturers and the retailer ends, signs of protests are rising from consumers around the world. The technology while tracking the product's life cycle poses a serious threat to privacy of the individual.

4.5 RFID tags become hacker target

According to Lukas Grunwald, a senior consultant with DN-Systems Enterprise Solutions GmbH., in addition to the wide protests regarding consumer privacy, RFID is more likely to have security issues as well.

4.6 Interference

Frequency interference and metal interference of the surroundings may interfere the proper working of the RFID setup involved.

5. Future of Libraries with RFID

Some voices say that Barcodes are enough to deal with the security issue, but RFID seems to be taking the front seat in this regard. A comparison of the two technologies highlights that why RFID is being preferred over Barcodes.

RFIDs	BARCODES
Can be read simultaneously.	Can be read one at a time
Excellent accuracy 99.9 %	Accuracy is 80%
Have memory of 8 to 32 MB.	Have Memory of 20 data char
Provide higher security as each tag is unique and impossible to duplicate.	Can be duplicated

University of San Francisco's public library has already started implementing RFID for keeping track of books Library officials have approved a plan to install RFIDs, into the roughly 2 million books, CDs and audiovisual materials patrons can borrow. The system was expected to be ready by the end of 2005.[5]

"Currently, approximately 120 million media and books in about 500 libraries worldwide are already attached with RFID labels," Birgit Lindl, a spokeswoman for Bibliotheca RFID Library Systems AG, based in Munich, Germany [6]

As libraries are implementing RFID systems, it is important to develop best practices guidelines to utilize the technology in best way and to keep the privacy concern away. The following may be the best practices guidelines for library RFID use (Berkeley Public Library n.d., Ayre 2004).

5.1 Best Practices for Libraries

- The Library should be open about its use of RFID technology including providing publicly available documents stating the rational for using RFID, objectives of its use and associated policies and procedure and who to contact with questions.
- Signs should be pasted at all facilities using RFID. The signs should inform the public that RFID technology is in use, the types of usage and a statement of protection of privacy and how this technology differs from other information collection methods.
- Only authorized personnel should have access to the RFID system.
- No personal information should be stored on the RFID tag.
- Information describing the tagged item should be encrypted on the tag even if the data is limited to a serial number
- No static information should be contained on the tag (bar code, manufacturer number) that can be read by unauthorised readers
- All communication between tag and reader should be encrypted via a unique encryption key.
- All RFID readers in the library should be clearly marked.

7. Conclusion

It is quite clear from the above discussion that an RFID system may be a comprehensive system that addresses both the security and materials tracking needs of a library. RFID in the library is not a threat if best practices guidelines followed religiously, that it speeds up book borrowing and inventories and frees staff to do more user-service tasks. The technology saves money too and quickly gives a return on investment.

It is important to educate library staff and library users about RFID technology before implementing a program. It may be good for librarians to watch developments in RFID until the cost of tags comes down to $.20 or less, the figure which some librarians have determined is the key to their serious consideration of it. While library RFID systems have a great deal in common with one another, including the use of high frequency (13.56 MHz), passive, read-write tags, lack of a standard and compatibility of tags produced by different vendors is a major problem in implementation of RFID in libraries. Current standards (ISO 15693) apply to container-level tagging used in supply chain applications and do not address problems of tracking and hot listing. Next generation tags (ISO 18000) are designed for item level tagging. The newer tags are capable of resolving many of the privacy problems of today's tags. However, no library RFID products are currently available using the new standard. Both cost and equipment may make RFID prohibitive in developing countries at this time.

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