Review

Implementing radio frequency identification technology in libraries: Advantages and disadvantages

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Radio frequency identification (RFID) technology is an innovative automated library system for automatic identification and tracking of library material. Currently, RFID applications range from book tracking and stock management, to theft detection and automatic book sorting. RFID technology is a dynamic link between people, objects and processes and in the near future it plays a prime role in data collection, identification as well as analysis necessary for specific library operations. An automated library with the support of RFID technology would be a "self service station" that demands least intervention by the library personnel. Efforts are being made to introduce self-service "check-in" and "check-out" that avoid long delay in the delivery of library material and also for achieving better efficiency in operations. RFID is used in libraries primarily to automate the book handling process including check-out, inventory control, check-in and anti-theft. When combined with computer assisted sorting equipment, RFID facilitates and speeds up even book sorting. Automating the library material handling process allows library professionals to spend more time with the clientele, thus, increasing the 'user satisfaction'. The potential benefits are obvious and the systems are getting cheaper. When the technology matures even more and competition increases in the industry, better tags and equipment will become more economical. It may only be a matter of time before radio frequency identification technology will completely replace barcode systems and become the standard for every organization. In this paper an attempt has been made to describe different components of RFID system. A detailed account of various applications of RFID technology in libraries has been discussed along with possible disadvantages of RFID system.

Key words: Radio frequency identification (RFID) technology, RFID system, reader, users, books, materials, information.

INTRODUCTION

Radio frequency identification (RFID) is a technology that enables wireless data capture and transaction processing. Radio frequency identification is an automatic identification method that relies on storing and remotely retrieving data using devices such as RFID tags or transponders. Apart from the new-age technologies like the Internet, e-commerce, bar-code systems, smart chips, RFID tool has given security solution and their application is helping enterprises and different sectors in various areas including libraries.

The main aim for today's libraries in adopting RFID is to improve library operations by increasing the efficiency of library transactions, reducing workplace injuries, and improving services for library users. Library manpower can be utilized to provide more value added services.

Modern radio frequency identification-based system reaches beyond security. It supports the tracking system which combines security with more efficient tracking of materials throughout the library. Various primary functions of library management, which include issue and return of documents, inventorying and materials handling become easier, faster and more efficient. Efficiency has always been the watch-word of library professionals

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across the world in their endeavor to provide improved service to the user community. RFID enables savings in costs-materials and manpower and ensures more efficient operations. RFID helps the librarian in providing the users with optimum utilization of available resources.

The paper have made a sincere effort to discuss different components of an RFID system and its advantages and disadvantages in libraries along with pictures to give an easy understanding of the discussions carried out.

What is radio frequency identification?

RFID is an acronym for radio frequency identification, which is a wireless communication technology that is used to uniquely identify tagged objects (Daniel et al., 2007).

According to Wikipedia, radio-frequency identification (RFID) is an automatic identification method, relying on storing and remotely retrieving data using devices called RFID (www.wikipedia.com).

Technovelgy.com has defined RFID as a small electronic device that consist of a small chip and an antenna. The chip typically is capable of carrying 2,000 bytes of data or less (www.technovelgy.com).

Radio frequency identification is a system that facilitates the tracking of objects, primarily for inventory tracking, via a three part technology comprised of a reader, a transceiver with decoder and a transponder (Radio Frequency-Tag). RFID is a wireless system that works in conjunction with an organization's information technology infrastructure to improve business processes such as inventory management and efficiency in supply chain management (Nisha et al., 2006).

COMPONENTS OF AN RFID SYSTEM

A comprehensive RFID system has four components:

1. RFID tags - these are electronic programmed with the unique information;
2. Readers or sensors to query the tags;
3. Antenna, and
4. Server - on which the software that interfaces with the integrated library software is loaded (Nisha, 2006).

RFID tags

The heart of the RFID system is a tag, which can be fixed inside a book's back cover or directly onto compact disc (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". 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 as per their requirements, 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, for example, the identification number of the item (Boss, 2003).

Tags are of three basic types:

1. Passive tags
2. Active tags
3. Semi-passive tags

They can also be read-only or provide read-write capability.

Passive tags

Passive tags have no built-in power source. Power is provided by the radio frequency wave created by the reader that includes in the antenna, a tiny but sufficient electrical current to activate the tag. When the tag comes into the ranges of the radio frequency wave field created by the reader, it uses that energy to power up its internal components and to communicate with the reader (Figure 1).

Active tags

Active tags have an internal power source (a battery) that provides the necessary power for the operation of the tag over a period of time. The higher the beeping frequency, the shorter the battery life, because active tags beep at specified intervals; the battery life is determined by the frequency of the beeps (Figure 2).

Semi-passive tags

Semi-passive tags are similar to active tags as they have their own power source, but the battery is used just to power the microchip. The radio frequency energy is reflected back to the reader like a passive tag. An alternative use for the battery is to store energy from the reader to emit a response in the future, usually by means of backscattering. Tags which do not have a battery need to emit their response reflecting energy from the reader carrier on the fly. Semi-passive tags are comparable to active tags in reliability while featuring the effective reading range of a passive tag. They usually last longer than active tags as well (Figure 3).
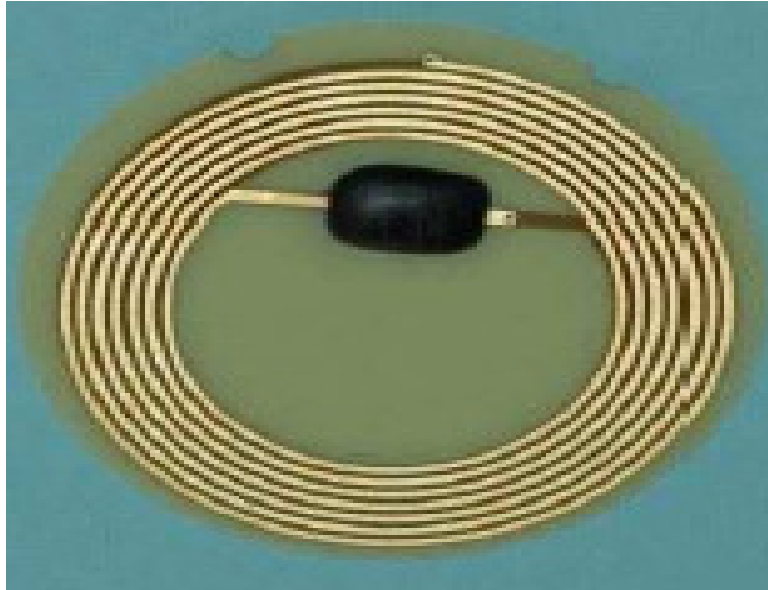
Figure 1. Passive tags.

Figure 2. Active tags.

Readers

Radio frequency identification 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. 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.

RFID exit gate sensors (readers) at library exit gates are basically of two types. One type reads the information on the tags 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 the circulation database.

Readers in RFID library are used in the following ways:

1. Conversation station: Where library data is written to

Figure 3. Semi-passive tags. Source: Allen Williams- Understanding RFID.

(i) Fixed reader   (ii) Hand-held reader   (iii) Mobile reader

Figure 4. Types of radio frequency identification readers. Source: www.symbol.com.

the tag.

2. Staff workstation at circulation: Used to charge and discharge library materials.

3. Self check-out station: Used to check out library materials without staff assistance.

4. Self check-in station: Used to check in library materials without staff assistance.

5. Exit sensors: To verify that all material leaving the library has been properly checked out.

6. Book-drop reader: Used to automatically discharge library materials and reactivate security.

7. Sorter and conveyor: Automated system for returning materials to proper area of library.

8. Hand-held reader: Used for inventorying and verifying proper shelving of library materials (Nisha et al., 2006) (Figure 4).

Antenna

The antenna produces radio signals to activate the tag and read/write data to it. Antenna is the channel 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. Antenna can be built into a doorframe to receive tag data from person's belongings passing through the door (Nisha et al., 2006) (Figure 5).

Sensor gate

The sensor gate is designed for the detection and reading of information from RFID labels, which are carried through a door.

The gate supplies the media number that shows which books were stolen. The reader consists of two or three antennas which are parallel to each other. The antennas show a similar design like the sensor gates used in stores for theft control. The aisle width is 90 cm (35 inches) with two antennas, and 1.8 m (70 inches) with three antennas (Kern, 2004) (Figure 6).

Server

The server is the heart of the comprehensive RFID system. It is the communication gateway among the various components. It receives the information from one or more of the reader and exchanges information with the circulation database. The server typically includes a transition database so that reports can be produced (Sujatha, 2007).

Figure 5. RFID antennas. Source: Allen Williams-Understanding RFID.

Figure 6. RFID sensor gate. Source: Texas Instruments, Inc.

Optional components

Optional RFID system includes the following three components:

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 into 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:

1. Screen the complete book collection on the shelves for inventory control;
2. Search for books which are not properly shelved;
3. Search for individual book requested.

External book return

It can also offer a distinct service that is very useful for users, such as the ability to return books, when the library

Figure 7. RFID setup in the library. Source: www.rfid-library.com.

is closed. An external book return is a machine with a slot with a chip RFID reader integrated into the wall. It works in the same way as the self checkout station. The user identifies himself/herself (if required by the library), and then puts the book(s) into the slot. Upon completing the return, the user will receive a receipt showing checked in; they can go directly back onto the shelves. These units can also be used with sorter and conveyor systems (Shahid, 2007).

RFID TECHNOLOGY APPLICATIONS IN LIBRARIES

Radio frequency identification

Technology has many advantages in library operations. The following section discusses few of them in detail. A typical RFID setup in the library looks like the one given in Figure 7.

Circulation

RFID systems provide efficient operation processing. Library circulation staffs do not need to scan barcodes one by one. Patrons can simultaneously process check in/out, verification, and entrance guard control with RFID reader equipment. Videotapes and diskettes are unable to use magnetic strips to enforce entrance guard because demagnetization will destroy the data on the material. Because RFID tags do not use demagnetization to modify data, they can use tags to manage magnetic materials the same way as the books. Library cards will include RFID tags. Readers will detect and fetch information from library cards when patrons enter a library, and it will be transmitted to a backend system

process. After that, the front desk shows loans, overdue, reserves, and other circulation status on the monitor about this patron. Librarians depend on these messages to provide service (Shien-Chiang, 2007).

Self check out

RFID check out system is user friendly, highly intuitive and reduces queuing times. At this station, the books to be checked out are placed on the desk and both user card and stack of books can be read simultaneously that is, recording the user's identification, the borrowed items and deactivating the antitheft. All this updating of the library databases happens automatically even for multiple items checked out by the same borrower. A receipt confirming the details of borrowed materials and due date is printed out (Koneru, 2004) (Figure 8).

Check in

Books can be placed on deck station (Figure 9) one by one without any intervention by staff. The returned items are instantaneously updated in the integrated library software and the anti-theft device is activated. This automated book return gives enhanced benefits to patrons as well as librarians. For patrons, it offers great flexibility in returning their material when they want and gives better availability of books as updating the library database is done in real time. Optionally, a receipt is also printed out to confirm the returning of borrowed materials. And for librarians, it saves time by avoiding certain repetitive tasks, since multiple items can be read/write at the same time and at a quick pace. It offers reliable book sorting system due to the fact that RFID tags can be read
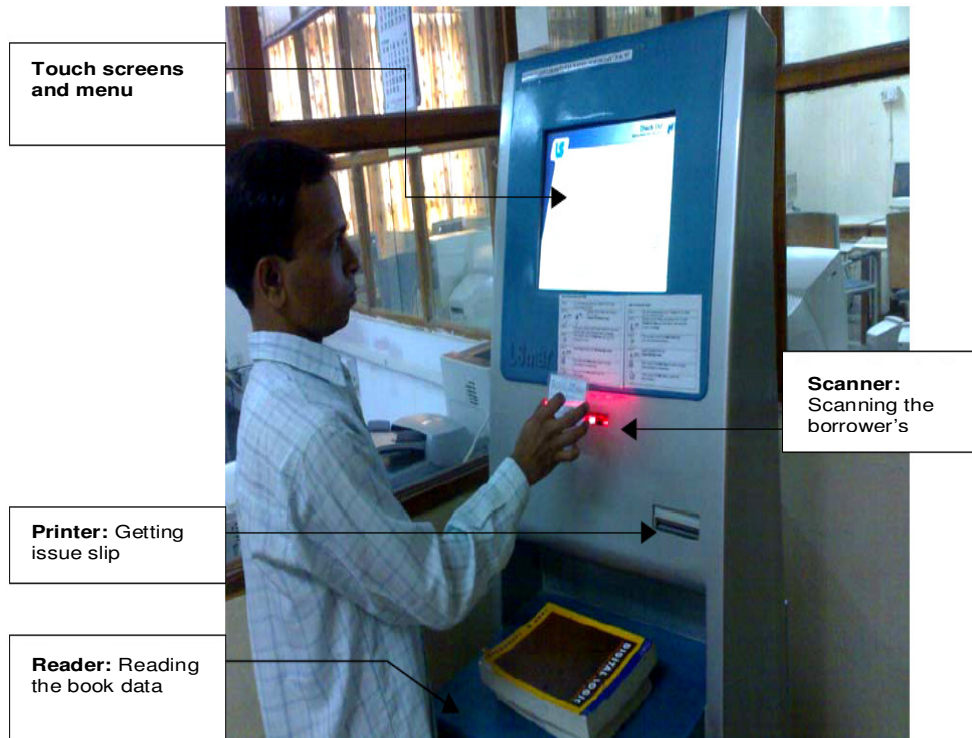
Touch screens and menu

Scanner: Scanning the borrower's

Printer: Getting issue slip

Reader: Reading the book data

Figure 8. Self check out.

Figure 9. Check-in.

quickly and independent of tag orientation or position (Koneru, 2004).

Inventory

A unique advantage of RFID system is the ability to scan books on the shelves without tipping them out or removing them to access the barcodes. A hand-held inventory reader can be moved rapidly across a shelf of books at a distance of approximately six inches 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.

Figure 10. Inventory.

Batch processing can also apply to libraries to perform inventory or shelf-reading.

Using hand-held readers to sweep shelves, for instance - readers can immediately detect all of the collection within this range, including abnormal situations such as books put on the wrong shelf (Figure 10). Specific advantages of using RFID in inventory control are as follows:

1. Reduce queues at the front desk;
2. Decrease repeatable tasks;
3. Increase interaction with patrons;
4. Extend internal security;
5. Lower the cost of manipulating and managing collections;
6. Procure collections, checking and accepting automation; and
7. Raise the efficiency of inventory and arrangement.

These advantages qualify radio frequency identification to replace barcodes and integrate with the RFID quick response. Durable characters promote operational efficiency and precision, while the cost is one of the major factors influencing acceptance of novel technology in libraries. This will stretch the budget and the schedule for implementation of RFID solutions difficult because some libraries hold enormous collections. Although RFID can improve efficiency, the essence of service will not change. Therefore, innovating services is an essential factor for libraries (Shien-Chiang, 2007).

Information management

Barcodes, book cards, and magnetic strips can all be integrated into one RFID tag. This type of RFID tag provides memory to record information and to supply the system. The memory not only stores bibliographic records and circulation status, but the system also traces the location of the specific collection. Depending on this service, the system can offer assistance in tracing service when looking for particular material in libraries (Koneru, 2004).

Assistance in searching and orientation

The application of RFID in industrial circles provides material flow management similar to library circulation. It also develops services such as assistance in searching and orientation based on detectable characters of RFID. One drawback of open-shelf libraries is that materials are easy to put on the wrong shelf or to be unaccounted for. Library automation systems can only query once about check in/out situations, but not where material is if it is not on the correct shelf. If a reader is installed on each gate in the library, as soon as a patron takes one material and enters another room, the system will detect who took it and where it is. This information will pass to the automation system to record the position of the material (Figure 11). This kind of service provides a more convenient management mode and improves the tracing

Figure 11. Assistance in searching and orientation.

of different locations (reference books, exhibits, featured collections) of material put on wrong shelves, as well as other unaccounted-for problems (Koneru, 2004).

Utilizing statistics for serials

There is no proper and accurate method to calculate the reading rate of magazines and that which are on the periodical rack. Systems do not record when they are used in open shelves and read in libraries. Patron response is uncertain if questionnaires are pasted onto magazines. Utilizing the detection scope of RFID, it is possible to collate materials from the periodical rack and readers. If readers remain undetected on one tag for a while this shows, that the magazine was taken off shelf and is being read (Shien-Chiang, 2007).

Guiding and personal service

Besides implementing RFID tags in a collection, utilizing frequencies of about 900 MHz UHF provides more detection scope to embed library cards and locations into RFID tags. Combined with patron data, environment position data, and collection data, process time and service mode completely record and manage information about people, events, times, places, and objects. When someone enters the library, the system identifies the patron's status, depending on the RFID tag in the library card. Thus, the library immediately acquires information about this patron and supplies appropriate personal service.

The library can be supplied with hand-held guiding equipment (reader and display device) for patrons to recognize the library environment. The system can automatically verify patron categories to decide the guiding scope, and is always detecting tags and retrieving information to show on screen at each position, such as at copy machines. Audio-visual materials can depend on being detected and recorded onto the tag in the library card. Combining charges and fines to a single payment mode can also be implemented.

Systems can create more service models when applying the mode of RFID wireless detection and combining it with different frequency and detection scope. The problems of implementation are cost and operation in coordination with suppliers. Therefore, when constructing a complete solution, planning the necessary accessories must be done with the supplier (Shien-Chiang, 2007).

Automated materials handling

Another application 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. Given the high cost of the equipment, this application has not been widely used (Das, 2007).

Sorting

When book is put on the deck, integrated library software (ILS) harnessing RFID flashes the accession number and shelf number, which facilitate shelving of items. And it provides additional information such as item belonging to
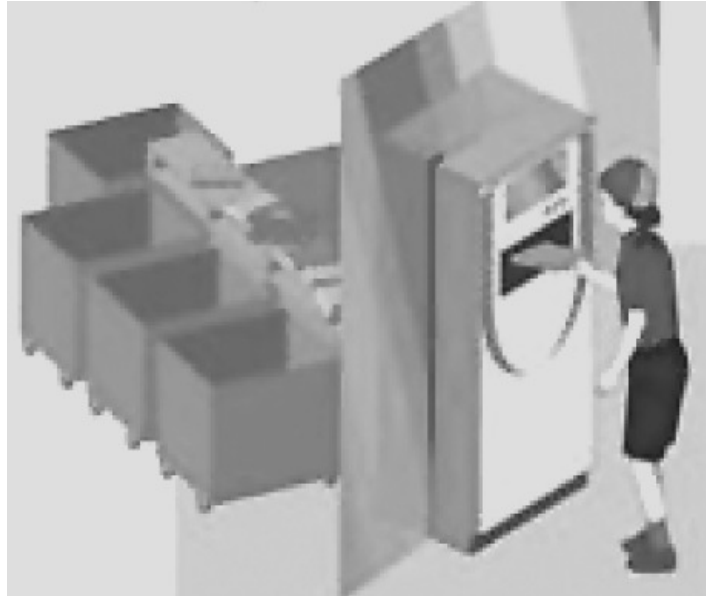
Figure 12. Book drop/book return station.

other location or if it is a reserved item, etc (Koneru, 2004).

Book drop/book return station

When books are returned through the 'Book Drop' facility of a library, the tags are automatically read and both patron record and library database gets updated. The theft detection system inside the tag is simultaneously activated. The book drop allows patrons to return items round-the-clock (Figure 12). A conveyor sorting system for books that are returned through the book drop can be installed (Patel, 2006).

DISADVANTAGES OF RFID TECHNOLOGY IN LIBRARIES

In spite of the overwhelming advantages and benefits with the use of the RFID systems in library operations and management, there are certain disadvantages too. Few of them are discussed following.

Invasion of patron privacy

There is a perception among some that RFID is a threat to patron privacy. That perception is based on two misconceptions:

1. That the tags contain patron information.
2. That they can be read after someone has taken the materials to home or office.

The vast majority of the tags installed in library materials contain only the item Identification (ID), usually the same number that between borrower and the borrowed materials is maintained in the circulation module of the automated library systems, and is broken when the material is returned. When additional information is stored on the tag, it consists of information about the item, including holding location, call number, and rarely author/title. The RFID tags can only be read from a distance of two feet or less because the tags reflect a signal that comes from a reader or sensor (Butters, 2007).

Maintenance of sensor and other components

The sensor/reader has to be maintained properly so that they are always in a trim condition and their power supply is always intact. While the short-range readers used for circulation charge and discharge and inventorying appear to read the tags 100% of the time. The performance of the exit gate sensors is more problematic. They always do not read tags at up to twice the distance of the other readers (Butters, 2007).

High cost

The major disadvantage of RFID technology is its cost. Return on investment has not been sufficiently documented in library literature, but as the use increases, the cost decreases and vice versa, that is, general growth in the industry may benefit library applications depending on its type, size and number of users (Boss, 2003).

Lack of standard

The tags used by library RFID vendors are not compatible even when they conform to the same standards because the current standards only seek electronic compatibility between tags and the information differs from vendor to vendor, therefore, a change from one vendor's system to the other would require retagging all items or modifying the software (Nisha et al., 2006

Uninterrupted power supply

Continued supply of power to the scanners and processors is very essential. Any generator back-up adds to the cost, besides occupying valuable space and generating undesirable noise with power (Shahid, 2007).

Vulnerability to compromise

It is possible to compromise an RFID system by wrapping the protected material in two to three layers of ordinary household foil to block the radio signal. Clearly, bringing household foil into a library using RFID would represent premeditated theft, just as bringing a magnet into a library using effective microorganisms (EM) technology would be. It is also possible to compromise an RFID system by placing two items against one another so that one tag overlays another. That may cancel out the signals. This requires knowledge of the technology and careful alignment (Rama et al., 2007).

Tag collision

Tag clash occurs when more than one chip reflects back a signal at the same time, confusing the reader. Different systems for having the tags respond to the reader one at a time. As they can be read in milliseconds, it appears that all the tags are being read simultaneously (Singh, 2007).

Privacy and data concerns

"RFID should be restricted by the state, radio frequency ID can be a boon, but who is tracking the trackers?" RFID transponders could potentially compromise the privacy of those who possessed them, including "tiny tracking devices the size of a grain of dust" which may be embedded in articles of clothing, etc. and used to track their unsuspecting wearers. Broadly, the most common discussions regarding privacy threats due to reduced data security in RFID systems can be sorted into two categories:

1. Threats involving the privacy of the borrower:

a. Tracking
b. Hotlisting and
c. Profiling.

2. Threats involving the library's collection:

a. Theft of library material
b. Digital vandalism and
c. Tag-based viruses (Shien-Chiang, 2007).

CONCLUSION

As a fledgling technology, RFID is starting to make an impact on the LIS activities. RFID has the potential to be a hugely significant technology. However, the benefits of a pervasive computing environment are unlikely to be realized unless the technology can be trusted. RFID has so far been implemented in developed and developing countries. It is widely acknowledged that there are genuine concerns around the implementation of the technology and it would be wise for administrators to make good use of its position within the community to initiate a pro-active approach to developments that will impact positively on library end users. The potential benefits are obvious and the systems are getting cheaper. When the technology matures even more and competition increases in the industry, better tags and equipment will become more economical. It may only be a matter of time before RFID technology will completely replace barcode systems and become the standard for every organization.

REFERENCES

Boss RW (2003). RFID technology for libraries [Monograph]. Library technology reports.

Butters A (2007). RFID Systems, standards and privacy within libraries. Electro. Lib., 25: 430-439.

Daniel H, Puglia A, Puglia M (2007). RFID: A guide to radio frequency identification. New York, John Wiley and sons, Inc., p. 1.

Das SK (2007). Fundamentals of RFID technology and its application in digital library system. In Ramaiah LS, Reddy S and Hemant K. eds. E-Libraries: Problems and perspectives. New Delhi: Allied Publishers Private Limited, pp. 626-643.

http://www.technovelogy.com (accessed on 21.12.2009).

Kern C (2004). Radio-frequency-identification for security and media circulation in Libraries. Electro. Lib., 22: 317-324.

Koneru I (2004). RFID technology: A revolution in library management. In 2nd International convention caliber-2004. Ahmedabad: Inflibnet center, pp. 412-416.

Nisha F, Bakhshi SI, Ali N (2006). RFID System: A boon for libraries. In 4th International convention caliber-2006. Ahmedabad: Inflibnet, pp. 554-555.

Patel DR (2006). Use of RFID technology in libraries. In 4th international convention caliber-2006, Ahmedabad: INFLIBNET, pp. 526-537.

Rama RE, Butidisuwan S (2007). RFID technology and its implementation in libraries. In Koganuramath MM, Kumbar, BD, Kademani BS. eds, CR Karisiddappa Festschrift volume on Library and Information Science Profession in the Knowledge Society, pp. 153-164.

Shahid S Md (2007). Use of RFID technology in libraries: A new

approach to circulation tracking, inventorying and security of library materials. Available at http://www.webpages.vidaho/edu/mbodinshahid.htm (accessed on 04.01.2010).

Shien-Chiang Y (2007). RFID Implementation and benefits in libraries. The electro. Lib., 25: 54-60.

Singh A, Singh, AP (2007). RFID: A revolutionary step towards new horizon. The Indian J. Tech. Edu., 30: 70-75.

Sujatha G (2007). Radio frequency identification (RFID) technology in library management. Pearl. 1: 22-24. http://www.wikipedia.com (accessed on 21.12.2009).