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Application of Radio Frequency Identification Technology in Libraries

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ABSTRACT

Radio Frequency Identification (RFID) systems were developed about 30 years ago. It is the latest technology to be used in libraries for book identification, for self checkout, and for sorting and conveying of library books and also for theft detection. These applications can lead to significant savings in labour costs and increase in efficiency. They can also reduce data entry errors, enhance customer service, and lower book theft and can provide a constant record update of media collections. The paper covers the components and technical features of a modern RFID library system to provide a guideline for the evaluation of this system. There are still many issues that must be addressed before RFID hits the big time. These include new technology for efficiency in operations, electromagnetic security systems, IT infrastructure to handle large amount of data, etc. Finally, the paper discusses the advantages and disadvantages of RFID system in libraries, and the extent to which this technology has been introduced in a few Indian Libraries.

Keywords: RFID, radio frequency identification, electromagnetic, DSRC, dedicated short-range communication

1. INTRODUCTION

Radio Frequency Identification (RFID) systems were developed about 30 years ago. They were used for "radio tracking" of wild animals and evolved later into a technology, which is used in many industrial applications today. RFID is a technology that uses electromagnetic or electrostatic coupling in the radio frequency (RF) portion of the electromagnetic spectrum to uniquely identify an object, animal, or person. RFID is coming into increasing use in industry as an alternative to the bar code. The most common applications are tracking goods in the supply chain, re-usable containers, high value tools and other assets, and parts moving to a manufacturing production line. RFID is also used for security, payment systems, and in libraries for circulation purpose. Thousands of companies and libraries around the world use RFID today to improve internal efficiencies.

2. WHAT IS RFID?

RFID is a term used for a radio-enabled device that communicates with or interrogates a tag or smart label, which is embedded with a single microchip processor and an antenna. In a library environment, RFID technology resembles a traditional bar code system. In bar code system, RFID provides a means of assigning an ID to an item and reading that ID to perform circulation transactions or to take inventory[1]. RFID (sometimes also called dedicated short range communication, or DSRC) uses the radio frequency portion of the electromagnetic spectrum to uniquely identify objects. Good old radio communications and new efficiencies in fabrication and miniaturisation go into RFID devices that can help organise the production and delivery of goods, and enable personal identification in efficient new ways.[2]

Like bar codes, RFID tags identify items. However, unlike bar codes, which must be in close proximity and line of sight to the scanner for reading, RFID tags do not require line of sight and can be embedded within packages. Depending on the type of tag and application, they can be read at a varying range of distances. In addition, RFID-tagged items can be read many times faster than bar-coded items. According to the Harrod's Librarian's Glossary and Reference book[3] "RFID is an alternative to the bar code that uses tiny microchips in tags to hold and transmit detailed data about the item

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tagged". Dictionary for Library and Information Science[4] defines RFID as "the use of microchips to tag library materials and library card, enabling users to check out items by walking through a self-service station equipped with an antenna that emits low frequency radio waves".

3. RFID APPLICATION IN LIBRARIES

RFID is the latest technology to be used in library for book identification, for self checkout, and for sorting and conveying of library books and also for theft detection. The aim of using RFID technology is to increase the efficiency, reduce data entry errors, and spare staff to perform more value-added functions[5]. 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 RFID 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 traditional theft detection systems do. Distance from the item is not a critical factor except in the case of extra-wide exit gates. The corridors at the building exit(s), and 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 sensors. The devices used for circulation and inventorying are usually called "readers" while the ones used at building exits are usually called "sensors."

The technology used in RFID systems can replace both EM (electromechanical) or RF and even the bar-codes theft detection systems.

4. HOW DOES AN RFID SYSTEM WORKS?

An RFID system consists of a tag, which is made up of a microchip with an antenna, and an interrogator or reader. The reader sends out electromagnetic waves. The tag antenna is tuned to receive these waves. A passive RFID tag draws power from field created by the reader and uses it to power the microchip's circuits. The chip then modulates the waves that the tag sends back to the reader and the reader converts the new waves into digital data (Fig.1).

5. COMPONENTS OF AN RFID SYSTEM

A comprehensive RFID system has four components:

(i) RFID tags that are electronically programmed with unique information;

(ii) Readers or sensors to interrogate the tags;

(iii) Antenna; and

(iv) A server or docking station on which the software that interfaces with the automated library system is loaded. It is also possible to distribute the software among the readers and sensors.

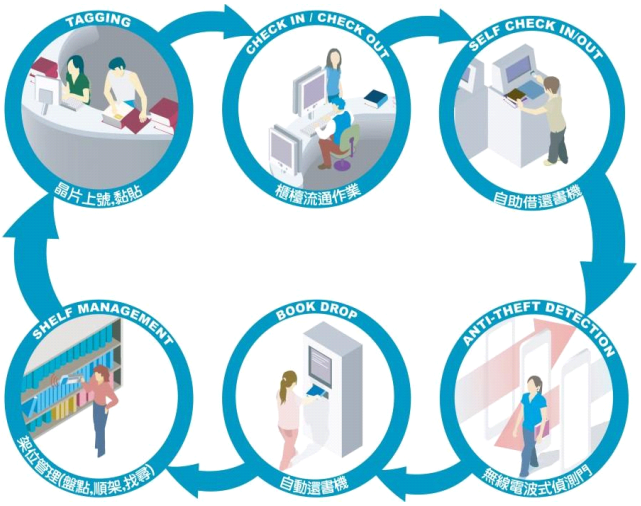

Figure 1. RFID management system.

5.1 RFID Tags

The chip and the antenna together are called an RFID transponder or an RFID tag. The tag is made up of a programmable microchip with an antenna. The antenna enables the chip to transmit the identification information to the reader[6]. The tag is a heart of RFID system. The tag can be fixed in side the book's back cover. Each paper-thin tag contains an etched antenna and a microchip with a capacity of at least 64 bits. There are three types: "read only", "WORM," and "read/write tags." Tags are "read only" if the identification is encoded at the time of manufacture and not rewritable. RFID tags can be read as long as they are within range of a reader. It depends upon the frequency of a tag. The frequency of a tag may be low, high and ultra high[5].

RFID systems are more expensive if they operate on higher frequencies. Different frequencies also have characteristics that make them more or less useful for particular applications. Low-frequency RFID systems use less power and are better able to penetrate non-metallic substances. They are ideal for scanning objects with high-water content such as fruits and liquids. Higher frequencies typically offer better range and can transfer data faster, but they use more power and are less likely to pass through materials. Higher frequencies are useful for air-to-air and air-to-ground communications.

The RFID tag stores data on a tiny computer chip. The cheapest and most common chip will be the read-only chip, which is likely to carry only a serial number. More expensive "read-write" chips allow new information to be added to the tag or written over existing information when the tag is within range of a reader. Writeable chips will be useful in some specialised applications such as maintaining maintenance records for vehicles or appliances, but they are more expensive than read-only chips and impractical for tracking less expensive items.

Once an RFID tag has returned data to the RFID reader, the data is then used in whatever way appropriate for the task at hand. Probably, the most common RFID systems will relate the serial numbers from read-only tags to other relevant and useful information in secure databases. RFID may be used to implement and record the sale of a consumer good at a checkout stand, to allow a keycard holder to enter a building, or for dozens of other purposes.[7]

An RFID tag is a means of storing and retrieving data through a radio frequency transmission to the chip inside the tag. An RFID tag is simply an integrated circuit (chip), which includes memory for data storage and a substrate backing material with an antenna pattern. The chip can typically hold up to 1,024 bits (128 bytes) of information. In a typical library implementation, each book is equipped with smart labels and library users are given library cards imbedded with smart labels.

Tags or smart labels can be programmed to store (i) unique accession number of documents; (ii) class number of a document; and (iii) a unique security code for EAS (Electronic Article Surveillance). While accession number is used for carrying out functions of circulation, stock verification and other library applications, class number can be deployed for sorting documents according to class numbers, and segregating then into bins for different shelving areas. As mentioned earlier, the RFID tags can also be used as antitheft devices in libraries. Such applications of RFID are called Electronic Article Surveillance (EAS). New forms of RFID perform EAS functions as well, obviating the need for a separate device[8].

5.1.1 Tagging Materials

A library planning on doing its own tagging should consider using volunteers in addition to its regular staff. This reduces both the time and cost of tagging. Only limited training is required; typically 15 to 20 minutes. While there is little choice with regard to the placement of tags on CD/DVDs and videotapes, there are many options for tagging books. It is important to select a consistent location for book tags. The inside of the back cover is the recommended location because it is the fastest for right-handed tag installers to reach. One vendor recommends it near the spine approximately three inches above the bottom. That avoids possible interference from metal shelves when inventorying[9].

5.2 RFID Readers

RFID readers or receivers are composed of a radio frequency module, a control unit and an antenna to interrogate electronic tags via RF communication. A system includes several different kinds of readers, also known as sensors when installed at library exits. These are RF devices designed to detect and read tags to obtain the information stored thereon. 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 decoded by the reader and sent to the server which, in turn, communicates with the automated library system when the RFID system is interfaced with it.

In a typical library application, RFID readers can be installed at various strategic places to support different functions that RFID tags can perform. Some of the typical installations could be:

- Workstation designed specifically for library staff to facilitate the smooth handling of books and other material having RFID labels/tags.
- The security gates with Theft Detection System. Any item that has not been checked-out either by staff station or self check-out station will be detected as it goes past these pedestals.
- Self-service station with provision for checking out books independently by the borrower without any intervention of library staff. The theft detection system of the smart label for that book is deactivated to enable smooth passage from the security gate.
- "Drop Box" where returned books are placed through suitable slits by users themselves. As books are returned through the Book Drop Facility located suitably in a library, the smart labels are automatically read, and both user record and Library database gets updated.

5.3 Antenna

The antenna produces RF waves to transmit signal that activates the transponder. Antenna is the channel between the tag and the reader, which controls the system's data acquisition 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.

5.4 Server/Docking Station

The server is the heart of some comprehensive RFID systems. It is the communications gateway among the various components. It receives the information from one or more of the readers and exchanges information with the circulation database. Its software includes the APIs (Applications Programming Interface) necessary to interface it with the automated library system.

6. ADVANTAGES OF RFID SYSTEMS

6.1 Rapid Charging/Discharging

- The use of RFID reduces the amount of time required to perform circulation operations. The information can be read from RFID tags much faster than from barcodes and that several items in a stack can be read at the same time.

- The other time savings realised by circulation staff are modest unless the RFID tags replace both the EM security strips or RF tags of older theft detection systems and the barcodes of the automated library system, i.e., the system is a comprehensive RFID system that combines RFID security and the tracking of materials throughout the library; or it is a hybrid system that uses EM for security and RFID for tracking, but handles both simultaneously with a single piece of equipment. There can be as much as 50 per cent increase in throughput. The time savings are less for charging than for discharging because the time required for charging usually is extended by social interaction with users.

- The use of RFID in libraries reduces the overhead of both librarians and users by reducing the time spent in charging/discharging and inventory check. In addition to it, RFID tags are highly reliable making almost 100 per cent detection rate and are scalable for future expansion.

6.2 Simplified Self-charging/Discharging

Unlike barcodes the RFID doesn't require direct line of sight making it easy and convenient to use. And for users using self-charging, there is a marked improvement because they do not have to carefully place materials within a designated template and they can charge several items at the same time

(i) It also reduces the man power utilisation in charging/ discharging, shelf management and inventory management of library. The use of self-service kiosks and book drops reduces the interaction of users with library staff making them free to do other work.

(ii) Some RFID systems have an interface between the exit sensors and the circulation system to identify the items moving out of the library. Were a user to run out of the library and not be intercepted, 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 sensors, an immediate alarm is triggered. Another option is to use both the "theft" bit and the online interface to an automated library system—the first to signal an immediate alarm and the second to identify what has been taken out.

6.3 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.

- Due to faster transactions, the items are available as soon as they are returned.

6.4 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.

- Compared to bar code, which takes five seconds per item for each transaction, RFID is more than three times faster for quick database update.

6.5 Long Tag Life

RFID tags are far better than bar codes, as these are not required to be scanned through some reader or recorder, as required in bar-code. Finally, RFID tags last longer than barcodes because nothing comes into contact with them. Most RFID vendors claim a minimum of 100,000 transactions before a tag may need to be replaced.

7. DISADVANTAGES OF RFID SYSTEMS

7.1 High Cost

The major disadvantage of RFID technology is its cost. While the readers and sensors used to read the information are costing between Rs100, 000 to Rs150, 000, a server is costing as much as Rs 500, 000 to Rs 600, 000. The tags cost Rs 30 to Rs 45 each.

7.2 Easy to Deceive the Technology

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 signals. 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.

7.3 Removal of Tags

RFID tags are typically affixed to the inside back cover and are exposed for removal. This means that there would be problems when users become more familiar with the role of the tags. In Indian libraries, it is a major challenge to keep the tags intact.

7.4 Exit Sensor (Reader) Problems

While the short-range readers used for circulation charge and discharge and inventorying appear to read the tags 100 per cent of the time, the performance of the exit sensors is more problematic. They must read tags at up to twice the distance of the other readers. The authors are not aware of any library that has done a before and after inventory to determine the loss rate when RFID is used for security.

7.5 Invasion of User Privacy

Privacy concerns associated with item-level tagging is another significant barrier to library use of RFID tags. The tags contain static information that can be relatively read easily by unauthorised tag readers. This allows for privacy issues described as "tracking" and "hot listing". Tracking refers to the ability to track the movements of a book (or person carrying the book) by "correlating multiple observations of the book's bar code" or RFID tag. Hot listing refers to the process of building a database of books and their associated tag numbers (the hot list) and then using an unauthorized reader to determine who is checking out items in the hot list.

7.6 Reader Collision

The signal from one reader interfering with the signal from another where coverage overlaps is reader collision. One way to avoid the problem is to use a technique called time division multiple access, or TDMA. In simple terms, the readers are instructed to read at different times, rather than both trying to read at the same time. This ensures that they don't interfere with each other. But it means any RFID tag in an area where two readers overlap will be read twice[10].

7.7 Tag Collision

Another problem readers have is reading a lot of chips in the same field. Tag clash occurs when more than one chip reflects back a signal at the same time, confusing the reader. Different vendors have developed different systems for having the tags respond to the reader one at a time. Since they can be read in milliseconds, it appears that all the tags are being read simultaneously.

7.8 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 readers. The pattern of encoding information and the software that processes 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.

8. IS RFID BETTER THAN BAR CODING?

The big difference between the two is that bar codes are a line-of-sight technology. A scanner has to see the barcode to read it, which means that the people who scan have to position the barcode towards a scanner for it to be read. RFID tags do not need line of sight. RFID tags can be read as long as they are within range of a reader. Since bar codes are inexpensive and effective for certain tasks, it is likely that RFID and bar codes will co-exist for many years. Until now, RFID has been too expensive and too limited to be practical for many commercial applications. But if tags can be made cheap enough, they can solve many of the problems associated with bar codes. Radio waves travel through most non-metallic materials, and can be embedded in packaging or encased in protective plastic for weather-proofing and greater durability.

Since the application of RFID in libraries is only a recent phenomenon, there are very few standards related to it. It is very important to know the use and importance of these standards. In the present scenario, RFID tags and RFID readers are proprietary, meaning, tags by a specific vendor can be read only by the readers supplied by them. "The market is likely to grow exponentially if some standards commonality is achieved, whereby RFID equipment from different manufacturers can be used interchangeably."[11]

Some organisations have come forward to address this issue by developing standards for specific applications. The International Organization for Standardisation (IOS) is working on standards for tracking goods in the supply chain using high-frequency and ultra-high frequency tags. Another organisation, EPC Global, has its own process, which was used to create bar code standards. Yet another issue hampering adoption of RFID systems has been cost. Since large companies would need thousands of readers to cover their huge manufacturing plants, warehouses, and stores the cost of deployment would be enormous[12].

9. RFID IN INDIAN LIBRARIES

While there are over 500, 000 RFID systems installed in warehouses and retail establishments worldwide, RFID systems are still relatively new in libraries. Several libraries have successfully installed the RFID solution. Since traditional security systems have proved to be less effective than libraries desire them to be and RFID is more effective in material management, one can safely say that the RFID solution is here to stay. Automation and self-service can help libraries of all size to achieve their operations. RFID is the need to increase efficiency and reduce cost. The products of six manufacturers of library RFID systems are available in India through their business associates Bibliotheca, Checkpoint, ID systems, 3M, Edutech, X-ident technology GmBh represented by Infotek software and systems in India, and TAGSYS represented by Tech Logic, Vernon, Libsys in India and VTLS. There are several other companies that provide products that work with RFID, including user self-charging stations and materials handling equipment.

RFID technology has been introduced in a few Indian libraries like NASSDOC (New Delhi), University of Pune (Jayakar Library, Pune), University of Jammu (J&K), Indian Institute of Technology (Madras), Indian Institute of Management (Indore), Bank of Baroda (Mumbai), Indian Institute of Science (Bangalore), Indian Institute of Technology (Kharagpur), Indira Gandhi Centre for Atomic Research (IGCAR, Kalpakkam).

10. CONCLUSION

The significant advantage of all types of RFID systems is the non-contact, non-line of sight nature of the technology. Tags can be read through a variety of substances such as snow, fog, ice, paint, crusted grime, and other visually and environmentally challenging conditions, where barcodes or other optically read technologies would be useless. RFID tags can also be read in challenging circumstances at remarkable speeds, in most cases responding in less than 100 ms. The read/write capability of an active RFID system is also a significant advantage in interactive applications such as work-in-process or maintenance tracking. Though it is a costlier technology (compared with barcode), RFID has become indispensable for a wide range of automated data collection and identification applications. Developments in RFID technology continue to yield larger memory capacities, wider reading ranges, and faster processing. It is highly unlikely that the technology will ultimately replace barcode, even with the inevitable reduction in raw materials coupled with economies of scale; the integrated circuit in an RF tag will never be as cost-effective as a barcode label. However, RFID will continue to grow in its established niches where barcode or other optical technologies are not effective. If some standards of uniformity are achieved whereby RFID equipment from different manufacturers can be used interchangeably, the market will grow exponentially.

REFERENCES

1. Lindquist, G. RFID in libraries–introduction to the issues. *In* 69th IFLA General Conference and Council, Berlin, *Germany,* 1-9 August 2003. http://www.ifla.org

2. Harper, Jim. RFID tags and privacy: How barcodes-on-steroids are really a 98-lb weakling. http://www.cei.org

3. Prytherch, Ray. Harrod's librarian's glossary and reference book. Ashagate, England. 2005.

4. Reitz, Joan M. Dictionary for library and information science. Rain Tree, Chennai. 2004.

5. http://en.wikipedia.org/wiki/RFID.

6. Singh, Gurdev. Introduction to computers for library professionals. Ess Ess, Delhi. 2007.

7. Harper, Jim. RFID tags and privacy. http://www.cei.org.

8. Chadha, R.K. ICT in libraries: An overview. http://www.cec-ugc.org/

9. Boss, R.W. RFID technology for libraries. http://www.ala.org/ala/pla/plapubs/technotes/rfidtechnology.html

10. Hussain, Akhtar. RFID in libraries. *IASLIC Bull.*, 2007, **52**(1).

11. Saiful, Amin. RFID tags. http://ncsi.iisc.ernet.in/pipermail/lis-forum/2004-November/001433.html

12. RFID Technology. http://www.cxtoday.com/India/Future_Technology/RFID_Technology/551-81807-907.html

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