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Use of RFID Technology in Libraries: a New Approach to Circulation, Tracking, Inventorying, and Security of Library Materials

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Introduction

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 cellphone. 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 (FAQ, 2004).

RFID for Libraries

RFID can be used 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.

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 two types. One 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).

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.

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.

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 are relieved further when readers are installed in book drops.

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.

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.

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.

Tag Life

RFID tags last longer than barcodes because the technology does not require line-of-sight. Most RFID vendors claim a minimum of 100,000 transactions before a tag may need to be replaced (Boss 2004).

Disadvantages of RFID Systems

High cost. The major disadvantage of RFID technology is its cost. While the readers and gate sensors used to read the information typically cost around $2,000 to $3,500 each; and the tags cost $.40 to $.75 each.

Accessibility 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 (Boss 2004). 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.

Removal of exposed 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 (Boss 2004). In Indian libraries, it is a major challenge to keep the tags intact.

Exit gate sensor (Reader) problems. While the short-range readers used for circulation charge and discharge and inventorying appear to read the tags 100 percent of the time (Boss 2004), the performance of the exit gate sensors is more problematic. They always don't read tags at up to twice the distance of the other readers. There is no library that has done a before and after inventory to determine the loss rate when RFID is used for security.

User Privacy Concerns. Privacy concerns associated with item-level tagging is another significant barrier to library use of RFID tags. The problem with today's library RFID system is that the tags contain static information that can be relatively easily read by unauthorized tag readers. This allows for privacy issues described as "tracking" and "hotlisting" (Ayre 2004).

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" (Molnar and Wagner 2004) or RFID tag. Hotlisting refers to the process of building a database of books and their associated tag numbers (the hotlist) and then using an unauthorized reader to determine who is checking out items in the hotlist.

Reader collision. The signal from one reader can interfere with the signal from another where coverage overlaps. This is called 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 (FAQ 2004).

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 (FAQ, 2004)

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 (Boss 2004).

Best Practices for Libraries

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):

- 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.
- ISO 18000 mode-2 tags should be used rather than ISO 15693.

Installations

While there are over 500,000 RFID systems installed in warehouses and retail establishments worldwide, RFID systems are still relatively new in libraries. Fewer than 250 had been installed as of the first quarter of 2004 (Boss 2004). Most installations are small, primarily in branch libraries. The University of Connecticut Library; University of Nevada/Las Vegas Library, the Vienna Public Library in Austria, the Catholic University of Leuven in Belgium, and the National University of Singapore Library are the only sites that appear to have tagged more than 500,000 items each. So far in India, only two University libraries have adopted the RFID system. First among them is Jayakar Library of Pune University and second is Dhanvantri Library of Jammu University. The use of RFID throughout Indian libraries will take at least four to five years.

Recent Developments

Recent developments in hardware and software for RFID systems have increased the potential of this technology in library automation and security. 'Today, the one important result for libraries is the ability to use non-proprietary systems, now that the new generation of RFID-chips with standard ISO 15693 (to be integrated into ISO 18000-3) is available,' explains Dr Christian Kern, system development manager of Bibliotheca RFID Library Systems, a Swiss company specialising in such systems for libraries. "With this technology, libraries do not have to depend on one single supplier for tags. As libraries make a long-term investment, which mainly consists of the quantity of tags needed, this is a very important requirement."

Vendors

The products of six manufacturers of library RFID systems are available in India through their business associates: Bibliotheca, Checkpoint, ID Systems, 3M, X-ident technology GmbH represented by Infotek software and systems in India and TAGSYS— the last 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.

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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