

RFID TECHNOLOGY FOR LIBRARIES

By Richard W. Boss

RFID (Radio Frequency IDentification) is the latest technology to be used in library theft detection systems. As of late 2005, an estimated 300 libraries were using RFID systems. Unlike EM (Electro-Mechanical) and RF (Radio Frequency) systems, which have been used in libraries for decades, 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.

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) and 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) 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 tags or targets used in RFID systems can replace both EM or RF theft detection targets and barcodes, although the system that 3M introduced in 2000 replaced only barcodes in the belief that EM is superior to RFID for security. [3M did introduce a comprehensive RFID product that replaces both EM and barcodes in 2004].

Advantages of RFID systems

Rapid charging/discharging

The use of RFID reduces the amount of time required to perform circulation operations. The most significant time savings are attributable to the facts that 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. While initially unreliable, the anti-collision algorithm that allows an entire stack to be charged or discharged now appears to be working well.

The other time savings realized 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. [3M has developed readers that can do both concurrently except for videotapes and audiotapes. These have to be desensitized and sensitized in a separate operation]. In either case, there can be as much as a 50 percent 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 patrons.

Simplified patron self-charging/discharging

For patrons 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. Patron self-discharging, which can be achieved by installing readers in bookdrops or with self-discharge stations, shifts work from staff to patrons.

High reliability

The readers are highly reliable. Several vendors of RFID library systems claim an almost 100 percent detection rate using RFID tags. Anecdotal evidence suggests that is the case whenever a reader is within 12 to 14 inches of the tags, but there appears to be no statistical data to support the claims.

There are fewer false alarms than with older technologies once an RFID system is properly tuned. The libraries contacted that have experience with both EM and RFID security systems, report a 50 to 75 percent reduction in false alarms with RFID.

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 patron to run out of the library and not be intercepted, the library would at least know what had been stolen. If the patron card also has an RFID tag, the library will also be able to determine who removed the items without properly charging them. However, the author has not been able to identify a library that has implemented this security feature.

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.

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 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 reshelving. Given the high cost of the equipment, this application has not been widely used. There were approximately 70 systems in use in North America as of the second quarter of 2005.

Long tag life

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.

Disadvantages of RFID Systems

High cost

The major disadvantage of RFID technology is its cost. While the readers and sensors used to read the information are comparable in cost to the components of a typical EM or RF theft detection system, typically \$2,500 to \$3,500 or more each; a server costing as much as \$15,000 may be required and the tags cost \$.55 to \$.80 each. It may be some time before the cost of tags comes down to less than \$.50 each, the price which random polling of librarians has determined is the key to their serious consideration of the technology. Gemplus, a European manufacturer of RFID tags, has predicted that it will bring a \$.50 tag to market within a year.

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 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.

Removal of exposed tags

3M, which recommends EM for security and RFID for tracking, argues that EM strips are concealed in the spines (30 percent of customers) or the gutters (70 percent of customers) of

books and are, therefore, difficult to find and remove; while RFID tags are typically affixed to the inside back cover and are exposed for removal. The author found no evidence of removal in the libraries he visited, nor did any of the library administrators contacted by telephone report a problem. That does not mean that there won't be problems when patrons become more familiar with the role of the tags.

If a library wishes, it can insert the RFID tags in the spines of all except thin books, however, not all RFID tags are flexible enough. A library can also imprint the RFID tags with its logo and make them appear to be bookplates, or it can put a printed cover label over each tag.

Exit sensor problems

While the short-range readers used for circulation charge and discharge and inventorying appear to read the tags 100 percent 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 author knows of no library that has done a before and after inventory to determine the loss rate when RFID is used for security. Lacking data, one can only conjecture that the performance of exist sensors is better when the antennae on the tags are larger.

Perceived Invasion of Patron Privacy

There is a perception among some that RFID is a threat to patron privacy. It is argued that the tags contain patron information and/or title information; and that the tags can be read from a distance after someone has taken the materials to home or office.

The vast majority of the tags installed in library materials contain only the item ID, usually the same number that previously has been stored on a barcode. The link between borrower and the

borrowed material is maintained in the circulation module of the automated library system, and—unless a library takes the unusual step of retaining patron borrowing histories—is broken when the material is returned. When additional information is stored on the RFID tag, it is limited to information about the item, typically holding location and call number, but rarely author and/or 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. It is, therefore, not possible for someone to read tags from the street or an office building hallway. In order to read tags from a distance of more than two feet, it would be necessary to greatly enlarge the tags or greatly increase the power of the readers. A library has no reason to purchase larger, more costly tags. An electrical engineer at N.V. Philips in the Netherlands estimated that it would require a truck mounted reader to read the tags used by libraries from a distance of more than ten feet.

One public library director recently suggested that it would be easier to look at the book jackets on the materials a patron was carrying out of the library or down the street than to hack the automated library system to tie a patron and a book together; and very much less expensive than constructing a high-powered reader to ascertain what library patrons had borrowed.

Perceptions, even when mistaken, may have real consequences. The Intellectual Freedom Committee of the American Library Association has responded to concerns about RFID raised by privacy advocates by drafting a set of principles:

- Implement and enforce an up-to-date organizational privacy policy that gives notice and full disclosure as to the use, terms of use, and any change in the terms of use for data collection via new technologies and processes, including RFID.
- Ensure that no personal information is recorded on RFID tags which, however, may contain a variety of transactional data.
- Protect data by reasonable security safeguards against interpretation by any

unauthorized third part.

- Comply with relevant federal, state, and local laws as well as industry best practices and policies.
- Ensure that the four principles outlined above must be verifiable by an independent audit.

The Council of the American Library Association adopted these principles on January 19, 2005. The Intellectual Freedom Committee has continued its work and introduced a set of guidelines for RFID use for discussion at the 2006 ALA Mid-winter Meeting in San Antonio. Among them, the following are the most significant:

- Libraries should not use RFID systems to track individual library users. Libraries should remove any personally identifiable information from statistical data collected by RFID system.
- Due to the potential for eavesdropping, libraries should use hardwire connections and not wireless connections for all communications between RFID systems and the ILS involving personally identifiable information.
- Libraries should encrypt information on RFID tags.
- Libraries using “smart cards” should use an “opt-in” system that allows library users to choose between “smart cards” and barcode-enabled cards.
- Libraries should be aware that independent researchers have concluded that current RFID technology cannot preserve user privacy in the library.

What problem is being addressed? Libraries are not using RFID systems to track individual library users. Patron information is stored only in the automated library system. The focus should be on the breaking of the link that exists within the automated library system as soon as an item is returned. Most libraries’ RFPs contain that requirement. Many also specify security requirements to protect against hacking.

Why limit the concern about wireless to RFID? A patron’s need for privacy is far greater

when searching the patron access catalog or the Internet. A library that uses wireless in its local area network should require that the network in its entirety be as secure as possible. That can be done using a combination of encryption and fiber optic cable.

The area in which RFID represents the greatest potential threat to patron privacy is the use of the “smart card” as a patron ID card. A “smart card” is an RFID card with encryption. That would make it possible to have the ID card also function as a “debit” card, with value added upon pre-payment to the library and value subtracted when a patron used a photocopier, printer, or other fee-based device, or wished to pay fines or fees. Almost none of the score of RFPs the author has examined include a mandatory requirement for ‘smart cards.’ The few that do, ask for that as an option. All stipulate encryption to protect patron privacy. The quality of the encryption is the key to patron privacy .

Because of the attention that has been focused on privacy issues, it is important to educate library staff and patrons about the RFID technology used in libraries before implementing a program. The best way to do that is to emphasize that RFID technology is not one technology, but several. E-Z pass is RFID that is meant to be read from a distance. It would be impractical to affix tags of that size and cost to library materials. The same is true of the tags used on pallets in warehouses. Further, a library should stress that it does not store patron information on the tags in library materials, that it protects patron privacy by breaking the link between borrower and material after the material is returned, and it subscribes to the privacy guidelines in the American Library Association’s Code of Ethics.

Several states are considering legislation that would pose restrictions on the use of RFID by retailers and libraries. It is, therefore, important to monitor legislative activity and to be prepared to inform legislators about the differences between retail and library applications, and how libraries protect the privacy of their patrons. Library administrators should be sure to keep their boards informed.

Components of an RFID System

A comprehensive RFID system has three components: (1) RFID tags that are electronically programmed with unique information; (2) readers or sensors to interrogate the tags; and (3) 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.

Tags

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 are “read only” if the identification is encoded at the time of manufacture and not rewritable. This type of tag contains nothing more than item identification. It can be used for items acquired after the initial implementation of RFID and by libraries that have collections without barcodes. Such tags need not contain any more than 96 bits.

“WORM” (Write-Once-Read-Many)” tags are programmed by the using organization, but without the ability of rewriting them later. They can be used when a retrospective conversion of a collection that is already barcoded is undertaken. The main advantage over read only tags is that information in addition to the identification number can be added. However, it must be information that won’t need to be changed. That could be an author and/or truncated title if the tag has enough capacity, but not library location or circulation status.

“Read/write tags,” which are chosen by most libraries, can have information changed or added. For example, a library might add an identification code for each branch. That information could be changed were the holding location subsequently changed. When a vendor includes a “theft” bit that can be turned on and off, the RFID tag can function much like an EM or RF tag. In library RFID, it is common to have part of the read/write tag secured against

rewriting, e.g., the identification number of the item.

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, rather than from a battery within the tag. “Active” tags, which have their own power supply, are substantially larger and more expensive than the tags used in library RFID applications. It is these tags that can be read at distances of up to ten feet.

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 another would require retagging all items or modifying the software. There is standards work underway to facilitate interoperability among the products of various vendors.

In late 2005, RFID tags cost from \$.55 to \$.80 each.

Tagging materials--A library planning on doing its own tagging should consider using volunteers in addition to its regular staff. That both reduces 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 near the spine approximately three inches above the bottom. That avoids possible interference from metal shelves when inventorying.

There is an argument about uniform placement of the tags. 3M suggests that three locations

should be selected to reduce the possibility that the tags of two or more books will alight exactly on top of one another and cancel one another out. Other vendors and several librarians who are using RFID say that they have not encountered problems.

Most libraries are not able to tag their entire collections at one time. They must, therefore, plan a phased implementation. A common approach is to convert materials not already tagged when they are being discharged from circulation. While it might seem desirable to do the conversion at the time of charging, that may create a bottleneck during busy periods. Regardless of whether it is done after discharge or as part of the charging process, it will only be a few months before the large majority of circulating items will have RFID tags. If this approach is used, the equipment at the circulation points will have to read both barcodes and RFID tags.

Retrospective conversion requires a “programmer” or “conversion station.” The purchase price is \$2,500 or more; rental approximately \$250 a week. The conversion of existing barcoded items, including affixing the tags to library materials, takes 15-30 seconds per item depending on the amount of information added to the tag and the skill of the person doing the tagging.

Pre-programmed tags, which are used for new acquisitions in libraries that want only identification numbers on the tags, take even less time because they do not involve scanning existing barcodes.

The speed of conversion can be increased by dividing responsibility for removing and replacing library materials, converting the barcodes, and inserting the tags among at least three people. It is essential that the tasks be rotated so that no one repeats the same motions over an extended period of time.

Almost all libraries tag new acquisitions as part of the cataloging process, however, libraries that have experienced losses of unprocessed library materials from technical services, might consider doing the tagging at the time of receipt in acquisitions. While inadvertent duplicates cannot then be returned, it should significantly reduce losses and facilitate tracking of items in technical services.

Readers

A typical system includes several different kinds of readers, also known as sensors when installed at library exits. These are radio frequency 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. While there is software in each reader to facilitate communication with the server and/or with library staff, most of the software supplied by the RFID system vendor is on the server when one is included in the system. When there is no server, most of the software is on the readers, although some may be on a docking station.

The types of readers include staff workstations for circulation desk charging and discharging, patron self-charging stations, and longer-range walk-through exit sensors to detect and read an RFID tag passage for purposes of determining whether it is a charged (authorized/no alarm) or discharged (non-authorized/alarm) event. The exit sensors are sometimes called “antennae,” but that is not correct because an antenna is only one component of an exit sensor. It is also possible to install a reader in a book drop to discharge materials as they pass the reader. Finally, there is a portable device that consists of a scanning gun attachment to read a group of items on the shelves for purposes of locating missing and misplaced items.

Programmers or conversion stations range in price from as little as \$2,500 to as much as \$5,000. Readers for use at the circulation desk typically cost \$2,500 or more each. They can be placed on the circulation counter or built-in. Discharging can be done on the same units, or on one or more dedicated units away from the service counter. Check-in is particularly rapid because the materials can be moved over the unit without regard to the orientation of the material and no conversation with patrons is involved.

Patron self-charging stations are similar to those which have been available for years and are similar in cost, approximately \$18,000-22,000. A number of models can support not only conventional barcoded library cards, but also magnetic strip cards and smart cards. Some models can also be used for patron self-discharging. That increases the cost of the unit by at least \$2,500.

A patron self-charging station can handle up to 20,000 transactions per month.

RFID exit sensors at exits look much like those installed in libraries for the last several decades, however, the insides are very different. One type reads the information on the tag(s) going by and communicates that information to a server. The server, after checking against the circulation database, activates an alarm if the material is not properly checked-out. The units cost \$3,500-6,000 each. 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. It is then not necessary to communicate with the circulation database.

. A bookdrop reader can automatically discharge library materials and reactivate security. 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. Bookdrop readers usually are the same as circulation desk readers and cost no more than \$2,500 plus the cost of installation into a

desk or wall. ATM-type units cost at least \$25,000, and an ATM-type unit with a sorter and five or more bins costs from \$45,000 to \$200,000 or more .

The portable scanner or inventory wand, which is priced at \$2,500 or more, can be moved along the items on the shelves without touching them. The data goes to a storage unit (\$2,000 or more) which can be downloaded at a docking station or a server later on, or it can go to a unit which will transmit it to the server using wireless technology (\$3,000 or more).

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. The server typically includes a transaction database so that reports can be produced. A server costs as much as \$15,000, more than two-thirds of which is the software. A vendor may choose not to use a server by substituting a less expensive docking station and increasing the amount of software in the readers.

Budgeting for RFID

A small library of 40,000 items should plan on a minimum budget of \$64,000 for an RFID system. The shopping list would consist of:

40,000 tags @ \$.70	\$28,000
1 programmer/converter rental (3 weeks)	750
2 staff stations @ \$2,500	5,000
2 exit sensors @ \$4,000	8,000
1 wireless portable scanner	4,500

1 server	15,000
222 hours of labor @ \$8.00	1,775
Carpentry and electrical	975

The labor cost assumes a conversion rate of three tags per minute.

A library with 100,000 items interested in patron self-charging and a book drop unit should plan on a minimum budget of \$147,000 for an RFID system. The shopping list would consist of:

100,000 tags @ \$.60	\$60,000
2 programmer/converter rentals (2 months)	4,000
4 staff stations @ \$2,500	10,000
1 patron self-charging unit	20,000
2 book drop units	5,000
3 exit readers @ \$4,000	12,000
2 wireless portable scanners @ \$4,500	9,000
1 server	15,000
556 hours of labor @ \$8.00	4,450
Carpentry and electrical	1,360

The labor cost assumes a conversion rate of three tags per minute.

A library with a collection of 250,000 items interested in patron self-charging and a book drop unit should plan on a minimum budget of \$283,500 for an RFID system. The shopping list would consist of:

2500,000 tags @ \$.55	\$137,500
5 programmer/converter rentals (2 months)	10,000
8 staff stations @ \$2,500	20,000
2 patron self-charging unit	40,000

3 book drop units	7,500
4 exit readers @ \$4,000	16,000
5 wireless portable scanners @ \$4,500	22,500
1 server	15,000
1375 hours of labor @ \$8.00	11,000
Carpentry and electrical	4,500

The labor cost assumes a conversion rate of three tags per minute.

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 300 had been installed as of the fourth quarter of 2005.

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.

The most ambitious RFID program is that of the Nederlandse Bibliotheek Dienst (Netherlands Library Service). It envisions implementing RFID in all of the public libraries of the country, with an item able to travel among libraries that are equipped to read the tags of all of the books, not just their own. A pilot system was installed in the public library in the city of Eindhoven in 2002. The vendor, Nedap N.V. of the Netherlands, uses Tagsys tags, but the equipment is also able to read the tags produced by Philips and Texas Instruments when the appropriate software is used. The deployment of RFID throughout the country will take four to five years.

Vendors

The products of six manufacturers of library RFID systems are available in North America: Bibliotheca (www.bibliotheca-rfid.com), Checkpoint (www.checkpointlibrary.com), ID Systems, recently renamed Sentry Technology Corporation (www.idsystems-dialoc.com), Libramation (www.codecolibrary.com), 3M (www.3M.com/us/library) and TAGSYS—the last represented by Information Technology Group (www.integratedtek.com), Tech Logic (www.techlogic.com) and VTLS (www.vtls.com).

There are several other companies that provide products that work with RFID, including patron self-charging stations and materials handling equipment. A major supplier of patron self-charging stations used by some of the RFID vendors is Optical Solutions (www.opti-sol.com); a major supplier of book drops used by some of the RFID vendors is Birchard (www.birchard.biz); and a major supplier of materials handling products that work with the systems of all of the RFID vendors is Tech Logic (www.tech-logic.com), a company that also sells complete RFID systems.

Differentiation Among RFID Systems

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, there are some significant differences:

1. An RFID system may be a comprehensive system that addresses both the security and materials tracking needs of a library by replacing both EM strips and barcodes or it may be a part of a hybrid system that uses EM strips for

security and RFID for materials tracking. All of the systems currently available are comprehensive RFID systems except for the hybrid system offered by 3M.

2. An RFID system may manage security by using a “theft” bit on the tag that can be turned on or off, or it may interface with an automated library system and query that system to determine the security status. Libramation and Tagsys use a “theft bit, 3M uses as “theft-bit” on its one-tag RFID system, Checkpoint uses an interface with an automated library system, and Bibliotheca uses both.
3. The RFID system tags may contain only an identification number or they may contain considerable additional information, some of which may be permanent and some capable of being rewritten. The 74 bit tag used by Tagsys and the 95 bit tag used by Checkpoint can accommodate only identification, the 256 bit tag used by 3M can accommodate a small amount of additional information, and the 1024 bit used by Bibliotheca and Libramation can accommodate considerable additional information.

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