

# **RFID TECHNOLOGY FOR LIBRARIES**

**By Richard W. Boss**

RFID (Radio Frequency IDentification) is the latest technology to be used in library theft detection systems. Unlike EM (Electro-Mechanical) and RF (Radio Frequency) systems, which have been used in libraries for decades, the RFID-based systems that libraries began to install in the late 1990s not only detect the unauthorized removal of library materials, but speed staff charge and discharge, speed and simplify patron self-charge and self-discharge, support electronic inventoring, and integrate with materials handling systems. The descriptive term “tracking systems” has been applied to RFID systems, but it is not yet in widespread use. As of mid-2007, an estimated 600 libraries with as many as 850 facilities were using RFID systems.

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. A reader (aka sensor, scanner or interrogator) looks for antennae on the tags and retrieves information from the microchips through them.

The tags used in RFID systems can replace both EM or RF theft detection barcodes and targets although the hybrid system that 3M introduced in 2000 replaced only barcodes and retained the EM strips 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 fact that information can be read from RFID tags much faster than from barcodes. That is due to the fact that the tags can be read

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 older technologies) 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. Finally, RFID tags can be read from distances of up to 24 inches—distances far greater than the use of lightpens and barcode wands used with EM technology. That is what makes RFID systems not only faster, but able to support electronic inventorying with handheld devices.

### ***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 18 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 by the author 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 (a term often used to describe readers that are used at exits) and a 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 integrated library system, the first to signal an immediate alarm and the second to identify what has been taken.

### ***High-speed electronic inventorying***

A unique advantage of RFID systems is their 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.

### ***Interfaces with materials handling systems***

Another application of RFID technology is an interface with a materials handling system, a system that consists of conveyors and sorting equipment that can move library materials and sort them mechanically 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 100 systems in use in North America as of the second quarter of 2007.

### *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 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 \$7,500 each, the tags are far more expensive than barcodes, EM strips, or RF targets. As of mid-2007, RFID tags were still approximately \$.50 each—a price which random polling of librarians by the author has determined is the key to their serious consideration of the technology.

### *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 exactly 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. Recently, the technology of tags has been improved to make them much thinner and more difficult to detect. The traditional manufacturing method, known as "solder and bond" created a detectable bump because the circuit on the chip attached to the antenna was raised; a latter method known as the "flip chip," fuses the chip onto the antenna, thus reducing the bump so that the tag is thin enough to conceal with a bookplate with a much less noticeable bump. A library can also imprint the RFID tags with its logo and make them appear to be bookplates.

### ***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 or when the exit lanes are 36 to 42 inches, rather than the 48 inches some libraries specify.

### ***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 and the readers that are available for the frequency range used in library tags are limited in their power to ten watts by law. 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 told the author that it would require a high-wattage truck-mounted reader to read the tags used by libraries from a distance of more than ten feet. Such a reader would violate the maximum wattage permitted for readers on the bandwidth used for library tags.

One public library director has 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 party.
- 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 systems.
- 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.

What problem is being addressed? Libraries have not used RFID systems to track individual library users. Patron information is stored only in the integrated library system. The focus should be on the breaking of the link that exists within the integrated library system as soon as an item is returned. Most libraries’ RFPs for integrated library systems contain that requirement. Many also specify other 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 a 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. The tag type and frequency of tags used in libraries cannot be read from a distance.

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 two major components: (1) RFID tags that are electronically programmed with unique information; and (2) readers or sensors to interrogate the tags.

#### ***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. The tags usually have a capacity of at least 256 bits.

“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. The tags usually have a capacity of at least 1024 bits.

A minimum capacity of 1024 bits is essential if the tags are to be used in electronic inventorying and/or with a materials handling system.

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 active tags that can be read at distances of up to ten feet.

The tags used by most vendors of library RFID 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 modifying all of the software.

In mid-2007, RFID tags cost an average of \$.50, with very large quantities reducing the price by 10 to 15 percent.

**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.

However, a library should consider placing the tags inside the front cover under a bookplate or with a bookplate printed on the tag. That may make the tag less apparent and, therefore, improve security.

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 align 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 may 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 stored, sent to a server, or communicated to an integrated library system when the RFID system is interfaced with it. 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 conversion stations, staff workstations for circulation desk charging and discharging, patron self-charging and discharging stations, book drop readers, 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. 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.

Conversion stations range in price from as little as \$2,500 to as much as \$3,500. 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 \$3,500.

A patron self-charging station can handle a minimum of 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 stores that information, communicates it to a server or docking station, or to the integrated library system. If there is a “theft bit,” an alarm will be activated and a turnstile gate locked if one or more items have not been properly charged. If a server is used, the server, after checking against the circulation database, activates an alarm if the material is not properly checked-out. The units cost \$3,500-7,000 each.

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 a materials handling system, including conveyors and sorters. Bookdrop readers usually are similar to circulation desk readers and cost no more than \$3,000 plus the cost of installation into a desk or wall.

ATM-type patron charge/discharge stations cost at least \$30,000. When combined with a conveyor and sorter with five or more bins into a materials handling system, the cost rises to a minimum of \$75,000. Some large libraries have spent well in excess of \$1 million for a materials handling system.

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*

A server or docking station may be configured with an RFID system. It is the communications gateway among the various components. It receives the information from one or more of the readers and checks the information against its own database or exchanges information with the circulation database. If the latter, its software includes the APIs (Applications Programming Interface) necessary to interface it with the integrated library system. The server typically includes a transaction database so that reports can be produced. A server costs a minimum of \$5,000, plus 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 \$46,000 for an RFID system without bookdrop readers, or patron self-charge/discharge. The shopping list would consist of:

40,000 tags @ \$.55	\$22,000
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
222 hours of labor @ \$8.00	1,775
Carpentry and electrical	975
Installation and training	3,000

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 \$121,310 for an RFID system. The shopping list would consist of:

100,000 tags @ \$.50	\$50,000
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 @\$3,000	6,000
3 exit readers @ \$4,000	12,000
2 wireless portable scanners @ \$4,500	9,000
556 hours of labor @ \$8.00	4,450
Carpentry and electrical	1,360
Installation and training	4,500

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 \$277,000 for an RFID system. The shopping list would consist of:

250,000 tags @ \$.50	\$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	9,000
4 exit readers @ \$4,000	16,000
5 wireless portable scanners @ \$4,500	22,500
1375 hours of labor @ \$8.00	11,000
Carpentry and electrical	5,000
Installation and training	6,000

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. Approximately 600 contracts had been signed by the middle of 2007. There were approximately 850 facilities using RFID.

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 among the few 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 at the public library in the city of Eindhoven in 2002, and the first operational system two years later in the public library in the city of Heimlo. 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 is expected to take a minimum of five years. Major Dutch jobbers are now including RFID tags in all library materials purchased from them. Approximately 80 percent of recent acquisitions by Dutch public libraries arrived with RFID tags.

## **Vendors**

There were eight major vendors of RFID systems active in the North American market as of mid-2007: Bibliotheca ([www.bibliotheca-rfid.com](http://www.bibliotheca-rfid.com)), Checkpoint

([www.checkpointlibrary.com](http://www.checkpointlibrary.com)), Information Technology Group ([www.integratedtek.com](http://www.integratedtek.com)), Libramation ([www.libramation.com](http://www.libramation.com)), Sentry Technology Corporation ([www.sentrytechnology.com](http://www.sentrytechnology.com)), Tech Logic ([www.Tech-Logic.com](http://www.Tech-Logic.com)), 3M ([www.3M.com/us/library](http://www.3M.com/us/library)), and VTLS ([www.vtls.com](http://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](http://www.opti-sol.com)); a major supplier of book drops used by some of the RFID vendors is Birchard ([www.birchard.biz](http://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](http://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.

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. A 74 or 95 bit tag can accommodate only identification, a 256 bit tag can accommodate a small amount of additional information such as location, and a 1024 or 2048 bit tag can accommodate limited bibliographic information for an item.
  
4. Some tags have a noticeable bump because they have been produced using “solder and bond” technology, while others have almost no bump because they use the “flip chip” technology that fuses the chip to the antenna.

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