

AN OVERVIEW OF RFID

(This chapter is adapted from "RFID Technology," by Richard W. Boss. Public Library Association TechNote, 2003.)

Theft detection systems, also known as EAS (electronic article surveillance) systems, have been used in libraries for decades. They are moving beyond that application to 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.

Theft detection systems

Two types of conventional theft-detection systems exist: electromagnetic (EM) and radio frequency (RF). The systems that combine theft detection and the tracking of library materials are radio frequency identification (RFID) systems.

Electromagnetic (EM) theft detection systems, of which thousands are installed around the world, operate on a magnetic basis. The targets consist of strips of metal with magnetic particles for degaussing.

Degaussing—neutralizing the magnetism—is accomplished by using high-powered magnets to negate the magnetic property of the strip. A library staff member rubs the area of the strip location with a magnetic device to turn off the strip, thus allowing the patron to pass through the security corridor created by the exit sensors without sounding the alarm.

When the materials are returned, they are resensitized, or turned on, by a library staff member. Security is the only application for this technology.

Radio frequency (RF) theft detection systems function much like electromagnetic theft detection systems, but they operate on a low-end radio frequency. The targets are always turned on.

To deactivate a target, insert a detuning card (a specially constructed date due card) into the card pocket to cover the target. This activity detunes or interrupts the signal and allows a patron to pass through the security corridor formed by the exit sensors. On return of the materials, a staff member removes the card to once again activate the target. Security is the only application for this technology.

Radio frequency identification (RFID) systems use radio-frequency-based technology combined with 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 (that is, the technology does not require line-of-sight or a fixed plane to read tags as do traditional theft detection systems). Distance from the item is not critical except in the case of extra-wide exit gates. The corridors at the building exit(s) can be as wide as 4 feet.

RFID systems can replace both EM or RF theft detection targets and barcodes, although for the last four years 3M has chosen to have it replace only barcodes in the belief that EM is superior to RFID for security. 3M plans to introduce a comprehensive RFID product that will replace both EM and RF in 2004.

Public Library Association, www.pla.org

Targets are attached to items so they can be tracked. Tags and magnetic strips are two types of targets.

Advantages of RFID tracking systems

Rapid charging and discharging

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

Although initially unreliable, the anti-collision algorithm that allows an entire stack to be charged or discharged now appears to be working well. Books that are not properly tagged or not the property of the library are ignored, however, rather than identified.

Another time savings for circulation staff occurs when 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. The system would be a comprehensive RFID system that combines RFID security and the tracking of materials throughout the library. Or it would be a hybrid system that uses EM for security and RFID for tracking but handles both simultaneously with a single piece of equipment.

In either case, as much as a 50% increase in throughput can be realized. The time savings are less for charging than for discharging because the time required for charging usually is extended by social interaction with patrons.

The best-known hybrid system is 3M's. It handles security using EM and tracking using RFID but has developed readers that can do both concurrently except for items that have magnetic properties (such as videotapes and audiotapes). The targets have to be desensitized and sensitized in a separate operation.

Simplified patron self-charging

For patrons using self-charging, RFID offers efficiency because patrons do not have to carefully place materials within a designated template. Patrons also can charge several items at the same time.

Patron self-discharging shifts the work from staff to patrons. Staff is relieved further when RFID readers are installed in bookdrops.

High reliability

The readers are highly reliable. Several vendors of RFID library systems claim an almost 100% detection rate using RFID tags. Anecdotal evidence suggests a 100% detection rate whenever a reader is within 12 to 14 inches of the tags. No statistical data supports these claims.

A properly tuned RFID system creates fewer false alarms than do older technologies. The libraries contacted that have experience with both EM and RFID security systems report a 50% to 75% reduction in false alarms.

Some RFID systems have an interface between the exit sensors and the circulation system to identify the items moving out 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 also can determine who removed the items without properly charging them (checking them out). Few if any libraries have implemented this security feature.

Other RFID systems encode the circulation status on the RFID tag. This encoding is done by designating a bit known 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 alarm immediately sounds. Another option is to use both the theft bit and the online interface to an automated library system—the first to signal an 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 out or removing the books. A librarian can rapidly move a hand-held inventory reader across a shelf of books to read all the unique identification information. Using wireless technology, the librarian can not only update the inventory but also identify items that are out of proper order.

Automated materials handling

RFID technology also performs automated materials handling, which includes conveyor and sorting systems that can move library materials and sort them by category into separate bins or onto separate carts. This application significantly reduces the amount of staff time required to prepare materials for reshelving. Given the high cost of the equipment, this application has not been widely used. About 35 systems were in use in North America as of mid-2003.

Long tag life

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 high cost. The readers and sensors used to read the information are comparable in cost with the components of a standard electromagnetic system 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 \$0.60 to \$0.85 each.

Some time may pass before the cost of tags is \$0.50 or less, the figure that a poll of librarians has determined is the key to their serious consideration of the technology. Gemplus, a European manufacturer of RFID tags, expects to bring a \$0.50 tag to market within two years.

Vulnerability to compromise

Any item in the RFID system can be compromised if a visitor wraps the protected material in ordinary household foil to block the radio signal. Bringing household foil into a library using RFID would represent premeditated theft, just as bringing a magnet into a library using EM technology would.

Another way to compromise an RFID system is by placing two items against each other so one tag overlays another. That overlapping may cancel the signals but requires knowledge of the technology and careful alignment.

Removal of exposed tags

3M, which has chosen to use EM for security and RFID for tracking, argues that EM strips are concealed in the spines (30% of customers) or the gutters (70% of customers) of books, making them difficult to find and remove. RFID tags are typically affixed to the inside back cover and are exposed for removal. Few if any librarians report removal of the strips, but perhaps patrons are just not yet familiar with the role of the tags.

If a librarian wishes, he or she can insert RFID tags in the spines of all except thin books, but not all RFID tags are flexible enough. Librarians also can imprint RFID tags with the library logo and make the tags appear to be book-plates, or they can put a printed cover label over each tag.

Exit sensor problems

Although short-range readers appear to read the tags 100% of the time, the performance of the exit sensors is more problematic. Exit sensors must read tags at up to four times the distance of the other readers.

Few if any libraries have done a before-and-after inventory to determine the loss rate when RFID is used for security. Lacking data, librarians can only suppose the performance of exit sensors is better when the antennas on the tags are larger.

Components of an RFID system

A comprehensive RFID system has three components:

- RFID tags that are electronically programmed with unique information
- Readers to read the tags

- In some systems, a server or docking station to receive and decode the information, and to communicate with the automated library system

Tags

Each paper-thin tag contains an etched antenna and a microchip with a capacity of at least 64 bits. Tags are available in one of three types: read-only; write-once, ready-many (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 tags are programmed by the using organization, but without the ability of rewriting them later. They can be used when a retrospective conversion of an already barcoded collection is undertaken.

The WORM tag's main advantage over a read-only tag is that information in addition to the identification number can be added—but this information must be that which won't need to be changed. The information could be an author 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 like an EM or RF tag. In library RFID, commonly part of the read-write tag is secured against rewriting, such as the identification number of the item.

The tags can be inserted in the items by a library, a book jobber, or the publisher at time of manufacture. Most libraries that have implemented RFID technology have done their own tagging.

Book jobbers that provide processing services are willing to insert RFID tags at additional cost, but publishers will not do so unless enough bookstores and libraries are willing to pay more for books with embedded tags. Demand is currently insufficient.

A library planning on doing its own tagging should consider using volunteers in addition to its regular staff to reduce the time and cost of tagging. Only limited training is required, typically 15 to 20 minutes.

Although little choice exists for the placement of tags on CD/DVDs and videotapes, many options are available for tagging books. Selecting a consistent location for book tags helps speed the insertion process because the placement decision is already made.

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 about 3 inches above the bottom to avoid possible interference from metal shelves when inventorying.

3M has a different view about uniform placement of the tags. It 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 out one another. Other vendors and several librarians who are using RFID say they have not encountered problems.

Most libraries are not able to tag their entire collections at one time. They must plan a phased implementation. A common approach is to convert materials not already tagged when they are being discharged from circulation.

Although doing the conversion at the time of charging might seem desirable, the conversion may create a bottleneck during busy periods. Regardless of whether you do it after discharge or as part of the charging process, a few months will pass before the 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.

The tags used by library RFID vendors may not be 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 differ from vendor to vendor, so a change from one vendor's system to another may require retagging all items.

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

Preprogrammed 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. Remember to rotate tasks so 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. Although inadvertent duplicates cannot then be returned, this process should significantly reduce losses and facilitate tracking of items in technical services.

Almost all libraries using RFID have tagged only library materials, but no reason exists not to tag small pieces of equipment. One academic library, which declined to be identified, has dramatically reduced losses by protecting everything that is not fastened down.

A few libraries have placed RFID tags on staff and patron identification cards. Not only does that application identify patrons for charging and discharging of library materials but also for access to restricted areas.

The system should allow librarians to code in the privileges of a patron. For example, an adult code would allow a patron to turn off the filtering software on a PC, but a child code would deny that option.

A smart card, which is an RFID card with additional encryption, is an alternative to merely adding an RFID tag to a patron card. That ability allows librarians to

make the patron card into a debit card, with value added on prepayment 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.

Readers

A typical system includes several kinds of readers, also known as sensors or interrogators. These radio frequency (RF) devices are designed to detect and read tags to obtain the information stored on them.

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 that, in turn, communicates with the automated library system when the RFID system is interfaced with it.

Although software in each reader facilitates communication with the server or with library staff, most software supplied by the RFID system vendor is on the server. When there is no server, most software is in the readers and, in some cases, in a docking station.

The types of readers include staff workstations for circulation desk charging and discharging, patron self-charging stations, long-range walk-through devices to detect and read an RFID tag passage for purposes of determining whether the item is a charged (authorized/no alarm) or discharged (nonauthorized/alarm) event.

The readers at exits are often called antennae, but that term is not correct because the antennae are only one component. In this report they are differentiated from other readers by calling them exit sensors.

You also can install a reader in a book drop to discharge materials as they pass the reader. Finally, a portable device is available 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. Staff workstations 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 unit, 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 that have been available for years and are similar in cost, about \$18,000 to \$22,000. A patron self-charging station can handle up to 20,000 transactions per month. Many models can support not only conventional barcoded library cards but also magnetic strip cards and smart cards.

Some models also can be used for patron self-discharging, which increases the cost of the unit by at least \$2,500.

RFID exit sensors at exits look much like those installed in libraries for the last several decades; however, the insides are 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 to \$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. This type doesn't require communication with the circulation database.

If RFID is used both for theft detection and tracking, a bookdrop unit can automatically discharge library materials and reactivate security. Since the materials have already been checked in, they can go directly back onto the shelves. The bookdrop units also can 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 \$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) that can be downloaded at a docking station or a server later on, or it can go to a unit that transmits it to the server using wireless technology (\$3,000 or more).

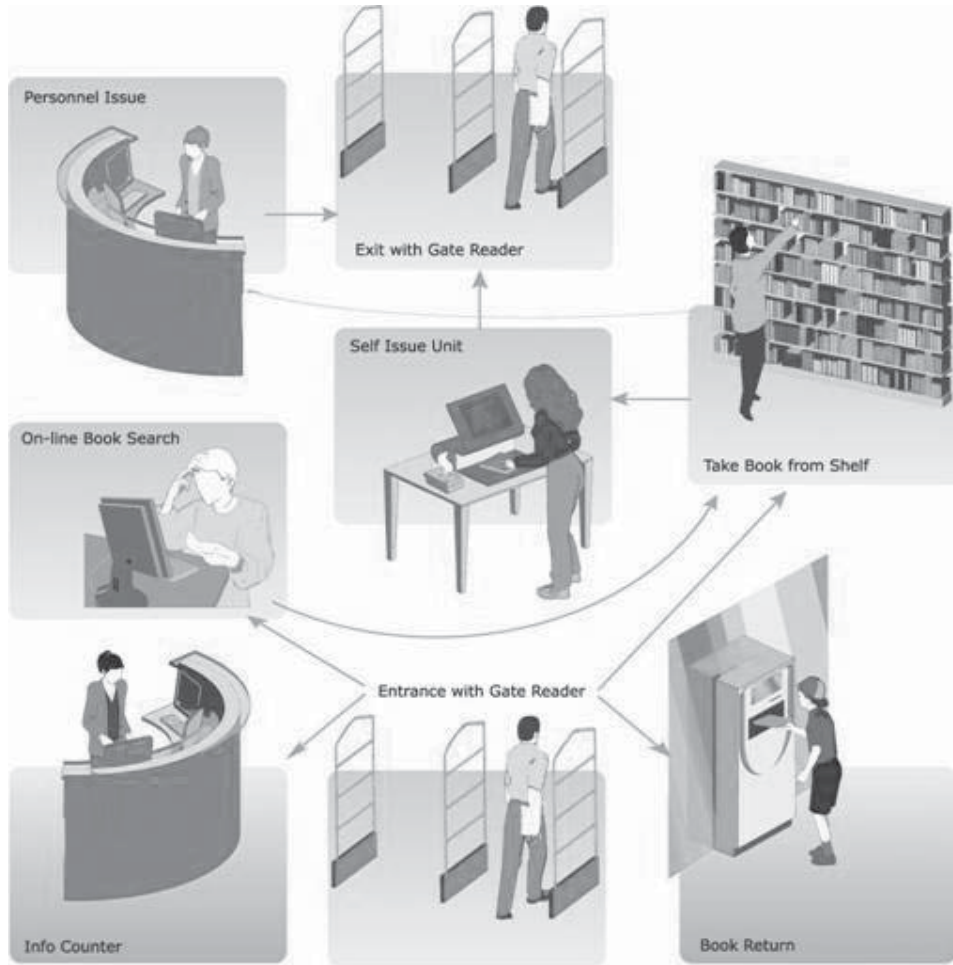
Server or docking station

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 interfaces) 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.

Schematic overview of an RFID system

The following illustration, supplied by Bibliotheca, shows the relationship among the components of an RFID system in a library:



RFID System Schematic.

Budgeting for RFID

A small library of 40,000 items should plan on a minimum budget of \$70,000 for an RFID system. The shopping list would consist of:

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| • 40,000 tags @ \$0.85 | \$34,000 |
| • One programmer/converter rental (three weeks) | \$750 |
| • Two staff stations @ \$2,500 | \$5,000 |
| • Two exit sensors @ \$4,000 | \$8,000 |
| • One wireless portable scanner | \$4,500 |

- One 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 bookdrop unit should plan on a minimum budget of \$166,000 for an RFID system. The shopping list would consist of:

- 100,000 tags @ \$0.85 \$85,000
- Two programmer/converter rentals (two months) \$4,000
- Four staff stations @ \$2,500 \$10,000
- One patron self-charging unit \$20,000
- Two bookdrop units \$5,000
- Three exit readers @ \$4,000 \$12,000
- Two wireless portable scanners @ \$4,500 \$9,000
- One 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.

Installations

Although more than 500,000 RFID systems are installed in warehouses and retail establishments worldwide, RFID systems are still relatively new in libraries. Fewer than 200 had been installed as of the middle of 2003.

Most installations are small and 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 the public libraries of the country, with an item able to travel among libraries that are equipped to read the tags of all the books, not just its 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 also is able to read the tags produced by Philips Semiconductors and Texas Instruments when the appropriate software is used. The deployment of RFID throughout the country will take four to five years.

Vendors

At least six manufacturers and four distributors of library RFID systems are in North America: Bibliotheca (also represented by Demco), Checkpoint, ID Systems, Libramation (formerly Codeco), Tagsys (represented by Tech Logic, Vernon, and VTLS), and 3M. A chapter is devoted to each of the manufacturers.

Several other companies provide products that work with RFID, including patron self-charging stations and materials handling equipment:

- A supplier of patron self-charging stations used by some RFID vendors is Optical Solutions.
- A supplier of book drops used by some RFID vendors is Birchard Co.
- A supplier of materials handling products that work with the systems of all RFID vendors is Tech Logic, a company that also sells complete RFID systems.

The addresses and URLs for all these companies are listed in Chapter 9.

Tyco, the company that sells the Sensormatic EAS system, is moving into the RFID market. Although it left the library market because of poor sales of its EM anti-theft systems, it may re-enter the library market with an RFID system. If so, the company is likely to use distributors, rather than pursuing direct sales.

Differentiation among RFID systems

Library RFID systems have much in common with one another, including the use of high-frequency (13.56 MHz), passive, read-write tags, but some significant differences exist:

- 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 the systems described in this report—except the system offered by 3M—are comprehensive RFID systems. 3M uses RFID as part of a hybrid system.
- 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, Checkpoint uses an interface with an automated library system, Bibliotheca uses both, and 3M relies on EM technology for security. ID Systems offers customers a choice.
- 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 1,024-bit used by Bibliotheca and Libramation can accommodate considerable additional information. ID Systems offers tags of many different capabilities.

The descriptions of the RFID vendors in Chapter 3 to 8 detail how each has decided to build its system.