Chapter 1

Library RFID Systems for Identification, Security, and Materials Handling

Abstract

Chapter 1 of Library Technology Reports *(vol. 48, no. 5) "RFID in Libraries: A Step toward Interoperability" discusses RFID systems being used by libraries today, which include tags, readers, and software. Libraries place tags in books and other library material to speed materials handling functions such as check-in and check-out and to provide security for the items. This chapter introduces the technology and explains how it is currently used in libraries.*

Library RFID systems are composed of tags, readers, and middleware software. The systems rely heavily on the integrated library system (ILS), and the middleware is designed to support communication between the reader and the ILS. Tags are placed inside library material, on media cases, or on multipart set bags. The readers are placed at staff workstations and self-check machines and built into security gates. At this time, most tags contain only the barcode number of the item and, in some cases, some additional information that can be used by the security system. The readers read the information on the tag (e.g., the barcode) and pass the information to the ILS.

RFID Tags

RFID tags come in many sizes and shapes and varying degrees of rigidity and flexibility depending on how they'll be used. They can be embedded in cardboard, plastic, wood, textiles, and even human or animal tissue. RFID tags can be found in thermal transfer labels, plastic cards, key fobs, and passports. When embedding the tags in a material, it is important to ensure that the components of the surrounding material protect the chip and antenna without creating interference during communications. Therefore, tags are manufactured for specific purposes.

Tags can be passive or active. Passive systems rely on the reader to generate the energy that will allow the tag to transmit the data on the chip. Active tags have their own transmitter and a power source (possibly a battery), so they can transmit the information stored on the chip without relying on the reader's power. RFID tags can be low frequency (LF), high frequency (HF), or ultra high frequency (UHF); see table 1.1. NFC (near field communication) is a kind of HF RFID tag.

The tags used in library applications are HF tags. They look like thin paper labels (see figure 1.1). In fact, some libraries imprint their library logo on the tags so they function as property labels as well.

Library book tags are designed to be placed into books. The antenna is tuned so that when the tag is placed inside the book, the book's material (book cover and paper) won't degrade, or detune, the signal. Items designed for CDs and DVDs are also specially tuned to work with the hard plastic that makes up a DVD or CD. Book tags wouldn't work well if used on a CD or DVD, and media tags wouldn't work well on a book because of the detuning effect of the material to which they are affixed.

Most libraries use HF tags for library applications because the read range is shorter and because the standards have thus far specified HF tags. However, the RFID marketplace is changing rapidly, driven largely by the popularity of UHF applications.

RFID Tags	Low Frequency (LF)	High Frequency (HF)	Ultra High Frequency (UHF)
Frequency	125 kHz	13.56 MHz	400 MHz to 1 GHz
Operating Distance	30 cm to 1 m	10 cm to 1 m	Passive: up to 25 m Active: up to 100 m
Characteristics	Short read range. Read range is easier to control. Handle metal and water better than UHF. Can be affected by industrial noise. Slower data transfer rate. Cannot always communicate with multiple tags.	Short read range (especially NFC tags). Read range easier to control than UHF. Not as effective as LF in presence of metal and water, but better than UHF. Unaffected by industrial noise. Can communicate with multiple tags simultaneously.	Long read range. Fast reading of multiple tags. Less tag memory than HF. Poor performance around liquids and metals. Operate in a crowded frequency.
Applications		Library materials management and security, access control, banking cards, contactless payment systems, goods control, security.	Asset tracking, supply chain, logistics, toll booths, real-time locating systems, container security, library material management and security (limited).

Table 1.1
Types of RFID tags

Figure 1.1
48 mm x 80 mm TAGSYS Folio 370-F3 tag. Photo provided courtesy of TAGSYS. See "Folio HF RFID Tags," datasheet, TAGSYS RFID website, 2012, http://tagsysrfid.com/content/download/463/3044/version/3/file/T-M-FolioTags-Datasheet-6Mar2012.pdf.

Book Tags

HF book tags come in two shapes. One is credit card size (figure 1.2) and one is square (figure 1.3). Both use NXP microchips, most often with 1,024 bytes of memory, and operate at 13.56 MHz. The different shapes are the result of the antenna design. The main manufacturers of library RFID tags are TAGSYS and SMARTRAC.[1] But libraries don't buy directly from the manufacturer. Libraries buy the tags from a library RFID vendor.[2]

Media Tags

The tags used for CDs and DVDs (figure 1.4) also come in two form factors: disk hub tags and full coverage tags. Hub tags fit on the inside ring of the CD or DVD and have not proven to be nearly as effective as the full coverage tags. The full coverage tags cover one side of the CD or DVD. The antenna is much bigger on these tags because it runs around the outside edge of the CD or DVD instead of the inside ring.

Two manufacturers make the full coverage tags: UPM Raflatac was the original manufacturer of the popular Stingray tag. Now that SMARTRAC owns UPM, the Stingray tag is simply known as the CDlabel.[3]

The other company making the full coverage tags was FCI Smartag, which manufactured the X-Range. This company has now been purchased by the Identive Group.[4]

UHF Tags in Libraries

When libraries first began using RFID, the only viable tag for item-level tracking was an HF tag. This is

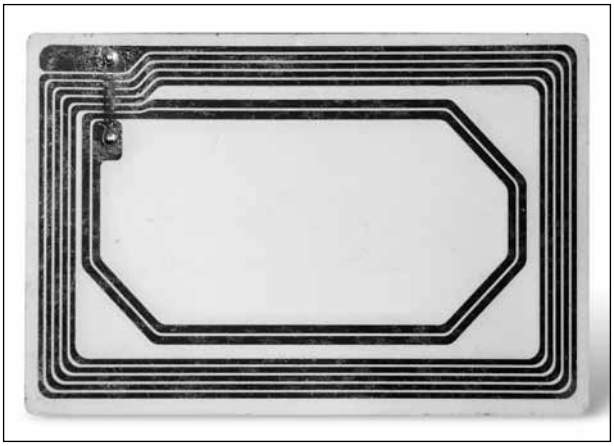

Figure 1.2
3M's ISO RFID tag. Photo courtesy of 3M. See "ISO RFID Tags," 3M website, http://solutions.3m.com/wps/portal/3M/en_US/3MLibrarySystems/Home/Products/RFIDTags.

because the read range of UHF is longer and more unwieldy than HF tags, and because early UHF tags encountered problems around metal and water. However, UHF technology has evolved quite a bit, and many RFID experts assert it is equally effective for item-level tracking. Some argue that it is a better choice than HF because UHF tags are more universal.[5]

However, virtually all US library RFID systems in production are based on HF tags.[6] There may soon be one exception. At the end of this year, Grand Rapids Public Library expects to go live with its UHF system. Grand Rapids has developed an open source solution for its UHF RFID system for communicating with its ILS (which is Evergreen, also an open source product). It is currently pilot testing and plans to go live with the new system in July 2012.

UHF technology has evolved very fast in the last several years and is now widely adopted for item-level tracking. Between 2003 and now, as other industries were focusing on UHF tags and developing standards and new applications across numerous industries, libraries continued to focus their standards efforts only on HF tags.

In 2006, EPC Gen 2 became the standard for item-level tagging with UHF tags. However, most library efforts to develop a data model and encoding standard have focused on the ISO 18000-3, Mode 1 standard for HF tags instead of the EPC Gen 2 standard for UHF. The exception is in Asia and to some degree in Australia. There are two proposals in the works that address the technical specifications of UHF tags for library use. At least one of them provides an approach that would help with interoperability across UHF systems (not between UHF and HF systems) and would leverage the data elements specified by ISO 28560-1 (for use with HF systems).

Figure 1.3
RFID Library Solution's square book tag. Image courtesy of RFID Library Solutions. See "RFID Products," RFID Library Solutions website, www.rfidlibrarysolutions.com/#!rfid-products.

Figure 1.4
A full coverage media tag (StingRay) ready to be applied.

Given the pervasiveness of UHF tags for item-level tracking in so many other industries, it isn't entirely clear that the decision to standardize on HF tags in libraries was the right choice. How to explore UHF tags for libraries without disrupting the progress made toward standardization and interoperability remains a conundrum for everyone involved in standards development. It is a question that should be resolved as

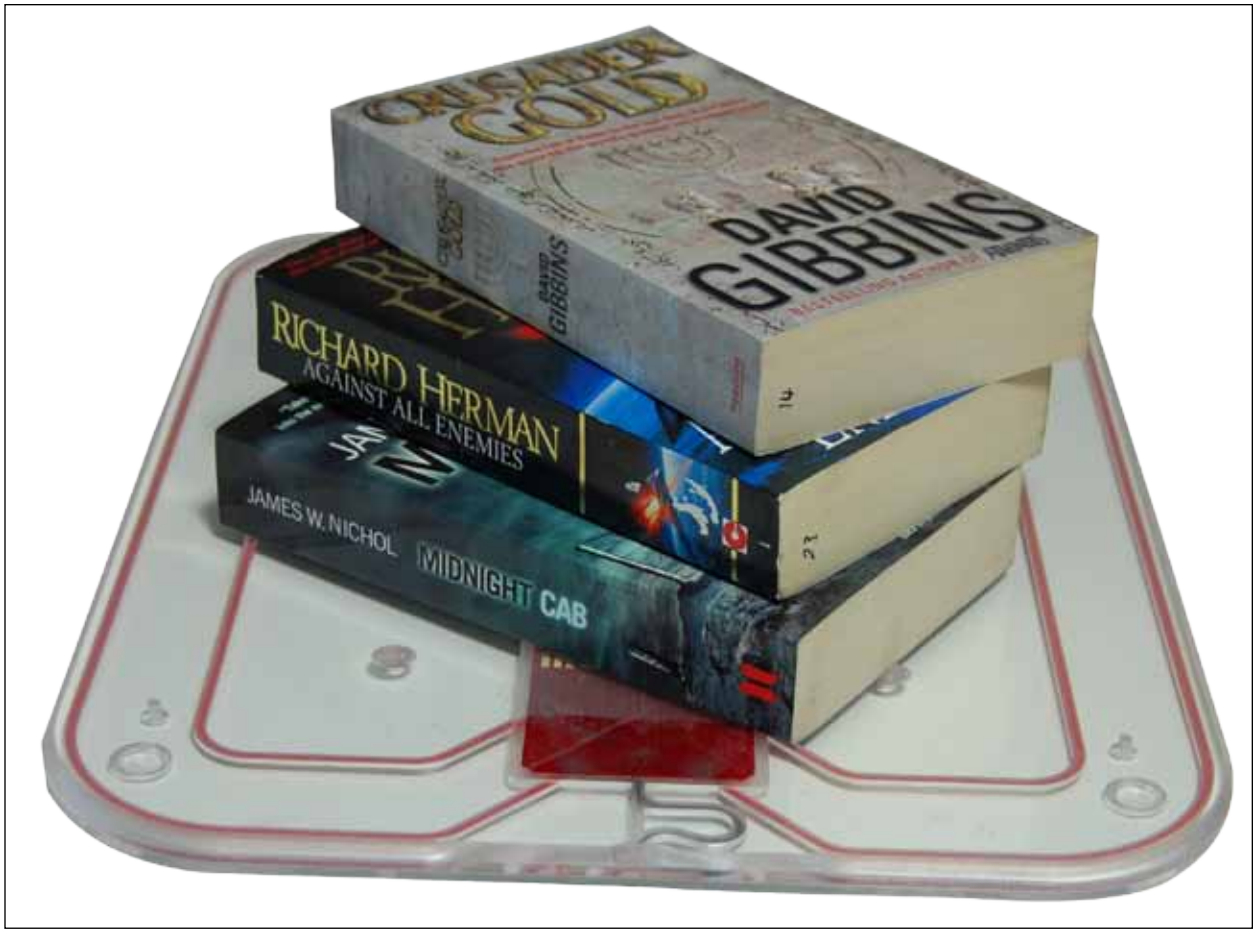

Figure 1.5
Example of an RFID reader that can be placed on top of the counter or underneath. Photo courtesy of Bibliotheca. See "Smartgate 100/200/300," Bibliotheca website, www.bibliotheca.com/1/index.php/gallery?productCode=s_station100.200.300&productTitle=smartgate%20100/200/300.

soon as possible so that libraries can move forward in unison and not at cross-purposes.

RFID Readers

Implementing RFID generally requires installing an RFID reader in every place where a barcode scanner is installed. This means that all staff workstations, self-check machines, and security gates must be configured with an RFID reader or replaced.

RFID-Enabled Staff Stations

RFID readers for staff stations are flat pads which can be placed on or under counters (figure 1.5). Once the material gets close enough to the reader, the tags are read and the data conveyed to the ILS. A stack of books can be placed in the pad's read range and as the tags are read, data is passed to the ILS.

The RFID readers used at staff workstations require that software be installed at the workstation to assist with the communication between the reader and the ILS. Sometimes the software is a "keyboard wedge," meaning it simply translates the data read by the device into keyboard data. Other times, the software is more sophisticated and enhances the circulation process. Some library RFID solutions work well with one ILS and less well with another. Therefore, before settling on an RFID solution, it is very important to test the software integration at staff workstations with your specific ILS.

Self-Check Machines

According to the 2012 Library RFID Survey[7] (an international survey in which 470 people from 278 libraries responded), 98 percent of libraries that have implemented RFID are using it for self-service.[8] This is because RFID-based self-check is easier for patrons to use because the patron doesn't have to identify the barcode and align the item properly. Patrons can just

Figure 1.6
Portable inventory system from Tech-Logic. Photo courtesy of Tech-Logic.
See "CircTRAK," Tech Logic website, www.tech-logic.com/solutions/rfid/inventory-control.asp.

set their books on the counter and the system begins reading them, making check-out very easy.

However, for RFID-based self-check to be widely adopted, patrons have to be able to do all of their check-outs at the self-check machine. If CDs or DVDs require staff intervention to open the case or get the media, or if some category of library material isn't RFID tagged, the percentage of self-service check-outs will be low. According to the 2012 survey, only 35 percent of respondents reported 85 percent or higher self-check use even though their systems were RFID based.[9]

Most self-check machines can be easily upgraded to support RFID.

Security Gates

Security gates are the second most implemented RFID product in libraries, after self-check machines. According to the 2012 survey, 85 percent of libraries that have implemented RFID are using them for security.[10]

Security gates used in libraries have traditionally used EM (electromagnetic) systems to detect items that have not been checked out. With an EM-based system, the item must be sensitized (security turned on) or desensitized (security turned off) as items are checked in and checked out. To turn on the EM system in a book or CD, the item is dragged past a magnet that sensitizes or desensitizes the strip. These sensitizers are bulky pieces of equipment that add a step in the circulation workflow (for both patrons and staff) and take up a lot of space on the countertop—or worse, require a staff person to do the sensitizing at a separate workstation equipped with such a unit.

RFID tags can be used for identification and circulation as well as security. Security is handled by changing one piece of information on the RFID's microchip as the item is checked in and out. It does not require an additional piece of equipment or additional work for the patron and staff.

The effectiveness of RFID versus EM security is roughly equal. Neither is perfect. Although several tags can be read at once, various conditions can result in items going undetected through the RFID security gates. If a person passes through the gates with a large number of picture books, it is more difficult to detect all the tags because the tags may be overlapping. When tags are close together and overlap, they can interfere with one another. Sometimes items can be missed if they are held in just the right position (e.g., the exact center of the gates where they may be just out of range

Figure 1.7
3M Digital Library Assistant. Photo courtesy of 3M. See "Digital Library Assistant," 3M website, http://solutions.3m.com/wps/portal/3M/en_US/3MLibrarySystems/Home/Products/RFIDCollectionManagement.

of both readers). Also, CDs and DVDs pose challenges for RFID systems because of the metal in some DVDs and because they too can overlap.

Despite these challenges, RFID security is as effective as EM security systems have been. They act as a theft deterrent, not as theft prevention. And unlike EM strips, they don't require additional processing (adding the EM strip) and handling (sensitizing and desensitizing).

RFID security should be used if a library is implementing an RFID system; however, better security shouldn't be the library's primary justification for switching from a barcode/EM system to RFID.

Converting from EM to RFID can be expensive as it may require replacing all the library's existing security gates. Recently, at least one vendor has made a hybrid security gate available. It's not clear how effective they are, however. According to the 2012 Library RFID Survey, the hybrid security gates are getting

Figure 1.8
EnvisionWare LibraryPDA. Photo courtesy of EnvisionWare. See "LibraryPDA," EnvisionWare website, http://envisionware.com/librarypda.

mixed reviews. In the United Kingdom, 50 percent of survey respondents reported they were happy with them, but 38 percent said they performed poorly. In the United States, 100 percent of respondents reported they didn't work very well.[11]

Mobile Readers

There are two form factors in library mobile readers: wands and handhelds (figures 1.6–1.8). Some of the mobile readers used for inventory are configured with long handles or wands in order to better read the tags on material shelved high and low. Other mobile readers are attached to handheld computers so the devices can be used for weeding, finding lost material, identifying items on the pull list, and shelf reading. These units often allow the staff person to download information to the device (e.g., weed list or lost items list) and have the ability to upload the updated information back to the ILS.

RFID Software

Every manufacturer of library RFID systems provides its own proprietary software to run its RFID equipment. In general, this goes beyond simply a "hardware driver" that allows the equipment to work with an operating system.

Sophisticated RFID software takes advantage of the fact that the data from several tags can be captured at once (unlike the "keyboard wedge" mentioned earlier). Rather than feeding the data to the ILS one keystroke at a time, numerous "calls" can be made to the ILS to get work done. These calls are usually SIP2 calls, meaning the RFID application communicates with the SIP2 server, which in turn communicates with the

ILS. Communicating with the SIP2 server is how all self-service check-out transactions are handled whether via barcode or RFID. The difference is in the middleware's ability to read all the tags at once, sort out the information needed to be sent, and sending only that information. The rest of the transaction is handled by the ILS and the self-check machine and has nothing to do with RFID specifically.

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But not all transactions can be handled by the library's SIP2 server. Some things that can be done with RFID hardware are not supported by SIP2. In this case, it is up to the RFID application to do the work. This applies to tasks such as weeding, inventory, and generating pull lists, and it could apply to many more functions as yet undefined. In these cases, the RFID vendor has written proprietary software that is the vendor's intellectual property. New protocols need to be developed so that RFID vendors can use standardized methods for accessing the ILS and sending data to the ILS beyond the basic circulation functions that are now supported by SIP2 and NCIP2.

RFID and AMH

Many people are under the mistaken impression that a library cannot implement automated check-in or sorting without RFID. In fact, automated materials handling (AMH) systems can function very well in either environment.

One-at-a-Time Check-in Systems

AMH systems that rely on a person feeding in items one at a time can use barcodes or RFID tags. The only difference is that the person inducting material into a barcode-based system must orient the material properly. If the item is placed with the barcode facing down or if the barcode is inside the book, the scanner won't be able to read it. AMH systems can be designed to open book covers or can be equipped with scanners above and below the items so the barcode *can* be read even if a patron inserts a book upside-down. Obviously, the system will cost a bit more if two scanners are needed at the induction points.

The advantage of one-at-a-time check-in systems (whether barcode- or RFID-based) is that each return is verified and the customer can get a receipt.

Book Drop Style Check-in Systems

Some AMH systems behave more like traditional book drops, allowing the patron to dump the books into a receptacle rather than feeding them in one a time. These systems can also be used with either barcodes or RFID tags.

Whether the items have barcodes or RFID tags, each item must be checked in one at a time eventually. To do this requires that the system move items up a slanted conveyor section at least two feet long. The conveyor is angled such that the library material slides apart and each item ends up separated (singulated) by the time it reaches the scanner or RFID reader.[12] If the system is barcode-based, it will be necessary to have scanners above and below the items to ensure the barcode can be scanned.

The key advantage to these drop-in types of systems is they are easier for patrons to use when they have a lot of material to return. There are two disadvantages to these systems. One is that patrons can't get a receipt for their returns because the items aren't checked in right away. The other is that this type of sorter takes up more room. Both of these disadvantages are a result of how the items are singulated after being dropped in.

The one type of book return that can be used with RFID, but not barcodes, is the RFID-enabled book drop (without the sorter). The book drop is simply configured with an RFID reader so that items get checked in as they are dropped in. The only advantage of these systems is for the customer who assumes all of the items have been successfully checked in. For staff, there is no advantage because each item will need to be checked in again to determine how it should be handled.

Notes

1. SMARTRAC bought two other big players in the market, UPM and KSW. For more information, see "SMARTRAC Further Strengthens Its Trusted Brand," news release, SMARTRAC website, March 1, 2012, www.smartrac-group.com/en/media-relations-latest-press-releases.php?type=pm_home&id=344&year=2012, and "SMARTRAC Completes UPM RFID Transaction," FreshNews.com, April 1, 2012, www.freshnews.com/news/631216/smartrac-completes-upm-rfid-transaction.
2. For a listing of vendors providing RFID products and services related to RFID, see "Buyers Guide," *American Libraries* website, http://americanlibrariesbuyersguide.com/.
3. See "CDlabel," datasheet, SMARTRAC Technologies,

2009, www.smartrac-group.com/en/download_2/datasheets/SMARTRAC_Datasheet_CD_Label.pdf.

4. See "Identive Group Announces Closing of Smartag Acquisition," news release, Identive website, November 22, 2010, www.identive-group.com/en/index.php?option=com_k2&view=item&id=156:identive-group-announces-closing-of-smartag-acquisition&Itemid=246.
5. J. Uddin, M. B. I. Reaz, M. A. Hassan, A. N. Nordin, M. I. Ibrahimy, and M. A. M. Ali, "UHF RFID Antenna Architectures and Applications," full length research paper, *Science Research and Essays* 5, no. 10 (May 18, 2010): 1034, www.academicjournals.org/sre/pdf/pdf2010/18May/Uddin%20et%20al.pdf.
6. Carver County (MN) has an RFID system, but it is not in production. It is doing tests in partnership with 3M. See NISO RFID Revision Working Group, *RFID in U.S. Libraries,* Recommended Practice of the National Information Standards Organization, NISO RP-6-2012 (Baltimore, MD: NISO, March 2012), 50, www.niso.org/apps/group_public/download.php/8269/RP-6-2012_RFID-in_US_Libraries.pdf.
7. Mick Fortune has been conducting surveys about library RFID use in the United Kingdom since 2009. In 2011, Alan Butters and I worked with him to make the survey applicable to our markets (Australia and North America), and we encouraged libraries in those two markets to respond. Fifty-one US libraries responded, compared to 115 from the United Kingdom and 58 from Australia plus several from 13 other countries. All of the survey responses can be found at Mick Fortune, "Search Results for: 2012 library rfid survey," *RFID—Changing Libraries for Good?* (blog), www.mickfortune.com/Wordpress/?s=2012+library+rfid+survey.
8. Mick Fortune, "Using RFID in the Library—Part 3 of the 2012 Survey," *RFID—Changing Libraries for Good?* (blog), March 6, 2012, www.mickfortune.com/Wordpress/?p=747#more-747.
9. Mick Fortune, "2012 Library RFID Survey: Self Service," www.libraryrfid.co.uk/useselfservice.html.
10. Mick Fortune, "2012 Library RFID Survey—Part 4," *RFID—Changing Libraries for Good?* (blog), March 8, 2012, www.mickfortune.com/Wordpress/?p=757.
11. Mick Fortune, "2012 Library RFID Survey—Part 6," *RFID—Changing Libraries for Good?* (blog), March 19, 2012, www.mickfortune.com/Wordpress/?p=775.
12. See the video "UltraSort Patented Item Deshingler" at "UltraSort Systems," Tech Logic website, www.tech-logic.com/solutions/ast/ultrasort.asp.