Chapter 2

THE TECHNOLOGY OF RFID

In this chapter the technology of RFID is explained in detail in sections about the tags, the readers, and the servers.

RFID tags

The three types of tags are read-only, WORM (write-once, read-many), and read-write:

- A read-only tag has an identification number encoded on it by the manufacturer.
- Once a WORM tag is programmed, it cannot be changed, but information can be added if space remains.
- A read-write tag can be erased or modified as required. Some library RFID vendors offer a read-write tag that has a lockable area where permanent data can be kept. The rest of the tag is rewritable.

Read-only tags require an interface to a database (such as the automated library system database) to determine whether an item has been checked out; the latter two types can have an on-off bit included to indicate the circulation status. This on-off bit is called the *theft* bit.

The use of a theft bit allows librarians to do the security check without querying the automated library system. When a theft bit is used, the interface is not needed, but it may nevertheless be desirable because a library would be able to identify what has been taken from the library. When an RFID tag also is on the patron card, the library is able to identify the patron who took the materials from the library.

Even though libraries add little information to read-write tags, these tags are by far the most popular type. Not only can they have a theft bit, but they allow librarians to add to tags in the future.

The paper-thin tags contain an antenna and a microchip with a capacity of at least 64 bits. That capacity is sufficient to store a unique identification number. If a tag is to store only an identification number and parity check bits, it doesn't need to have a capacity of more than 128 bits.

Parity bits are additional numbers that will, when added to a number, result in an expected total. If they do not, then a faulty read occurred.

Tags of up to 256 to 1,024 bits are always programmable and can carry much information in addition to an identification number. They are almost always programmed by the user as the additional information is rarely available to the manufacturer of the tags.

More tag memory results in a higher cost of the tag. A vendor may choose, however, to take a lower markup on a tag with greater capacity than that of another vendor to remain competitive.

The more tag memory, the faster the readers have to read the information to not slow the response of the system. Vendors that use high-capacity tags use more powerful readers, especially at the exits of a library.

The capacity of the tags differentiates RFID from RF-based EAS (electronic article surveillance) systems. Although RF-based EAS systems also rely on

radio frequency, the tags typically consist of a conductive foil sandwiched between two leaves of paper. They are often disguised as date-due cards and placed in a pocket that contains an RF tag.

The placement of the foil adjacent to the tag detunes the circuit so it no longer resonates at the frequency generated by the detection system, so the alarm is not activated as the item is taken from the library. RF detection systems are susceptible to false alarms because they may alarm on anything that resonates in the field. Metal window frames are a major source of problems.

Although RFID tags are available in many shapes, the ones used in libraries typically are 1.8 inches by 2.0 inches, 2.0 by 2.0 inches, or 2.0 by 3.0 inches in size and 500 microns thick where the chip is embedded. A peel-and-stick adhesive facilitates affixing the tag to an object.

CDs have special donut tags and videocassettes have rectangular tags. The larger the size of the tag, the larger the antenna on it—and the greater the distance at which it can be read.

For tags to work they require power. The level typically is measured in microwatts (millionths of a watt) or milliwatts (thousandths of a watt). Tags are either active or passive, the designation being determined by the manner in which the tag derives its power.

Active tags are powered by an internal battery and are typically read-write. Active transponders allow greater read range and higher transmission rates than passive ones, but they are more expensive.

Passive tags operate without an internal battery source. They derive their power from the field generated by the reader, so they are less expensive to produce. The tags used in library RFID are passive. The smaller the tag, the smaller the energy capture area, resulting in a shorter read range. A larger tag can be read from a greater distance, so exit sensors can be placed farther apart.

Additionally, chip designs also make a difference in power requirements. A chip design that offers more efficiency or operates at a lower voltage may result in a higher range for a given energy capture area.

The tags used in libraries are 13.56 MHz tags. This megahertz produced is a high-frequency band defined by the ISO 15693-2 international standard.

ISO: International Organization for Standardization

The standard specifies how data is passed between tags and readers and defines a minimal set of commands. The radio frequency field at 13.56 MHz is not absorbed by desktops, book covers, or human skin, so no line of sight is required.

Extensive testing has established that this frequency can be used without any reservations regarding human safety. The read range depends on the energizing requirements of the tag and the power of the antenna. At a minimum, the tag can be read from a distance of 4 feet.

Electrical noise from motors and fluorescent lights is minimal at 13.56 MHz. The frequency has no effect on mobile phones and other devices that use radio frequencies because these devices use narrow-band radio signals and at frequencies far from 13.56 MHz.

Much of the confusion about the cost of library RFID tags is because the less expensive inventory control tags used in retailing are in the low-frequency band (30 to 300 KHz). Although tags in this low range are less expensive to produce, they have low reading speeds.

Generally, the lower the frequency, the slower the data transfer rate. The tags in a stack of books would take too long to read if the inventory control tags used in retailing were adopted by libraries. For that reason, a different type of tag that is more expensive is required. Don't assume library RFID tags will drop dramatically in price to the $0.05 to $0.25 level of retail tags when larger quantities are purchased.

All vendors in the library RFID market offer products that can read several tags seemingly simultaneously. This simultaneous reading is accomplished with anti-collision technology—a technology that sorts out the signals from the various tags. The minimum number recommended is as few as three and the maximum is as many as eight.

Vendors can add a signature to a tag that makes the equipment of other vendors unable to read the tags. If a library purchases such tags, it removes the possibility of benefiting from technology developments from alternate suppliers.

Bibliotheca and Tagsys produce their own tags. The tags used by other vendors are available from tag manufacturers such as Mitsubishi Materials, Texas Instruments, and Lucatron (now owned by Bibliotheca), although they have often been customized in response to the specifications developed by the vendors. The chips used in the tags are available from yet other suppliers, among them Philips Semiconductors, Texas Instruments, and Siemens Electronics.

Readers

Several types of readers are available, but each generates a field of power to read tags within range. The power within a tag is generally less than that emitted by a reader, requiring sensitive detecting capability to handle the return signals.

In a space free of any obstructions, the strength of the field reduces in inverse proportion to the square of the distance. For example, if the distance is increased from 2 to 4 feet, the strength of the field is reduced 75%. Choose the differing power levels for devices based on the distance at which they are to read the tags.

Most RFID readers used in libraries are mid-range readers that read at distances of up to 16 inches. That distance obviates the need for contact with the tags and also avoids accidentally reading the tags on another person's materials.

On the other hand, the exit sensors are long-range readers capable of reading tags in a corridor width of as much as 48 inches. A staff workstation or patron self-charging station requires less power than a sensor at the exit of a library.

The heart of a reader is called a transponder, a word derived from transmitter-responder. A tag responds to a transmitted request for the data it carries and sends the information to the receiver. When distances of more than 14 inches are involved, the receiver typically operates at a higher power than the transmitter because of the weak signal sent by tags.

Although all the readers in library RFID systems can read 13.56 MHz tags, they cannot read the IC chips of all vendors because each vendor adds proprietary elements to its tags.

When a reader accommodates the IC chips of several manufacturers—Philips, Tagsys, and Texas Instruments are the most widely used—it captures the information and sends it to a server or docking station. The software may not be able to use the information because the data format and content are not familiar. See the discussion on standards at the end of this chapter for more information.

Conversion station

A conversion station, also known as a programmer, tagging station, or reader-writer, can be used to transfer the identification number to an RFID tag by keying or scanning a barcode.

In the case of read-write tags, the conversion station also can be used to rewrite information on the tag. Some vendors offer portable carts to facilitate undertaking conversion in the stacks. Incorporating this function into staff workstations also is possible.

Staff workstation

A staff workstation at circulation can be used to charge and discharge materials, both singly and a stack at a time. The maximum number of items typically is eight to 10.

The staff workstation indicates the number of items read so that the operator can determine whether it matches the number presented to the reader. If not all were read, the stack probably contains a book without a tag. That circumstance is the most common source for delays in check-outs.

Patron self-charging station

A patron self-charging station is similar to that which has been offered for use with barcodes, but it is faster and easier to use because materials do not have to be carefully placed on a template.

Again, the major complication in self-charging is a failure to read all the items in a stack because the stack contains a book without a tag.

Exit sensors

Though similar in appearance to the devices used with EM and RF technology, the RFID exit sensors—which also are called antennae and interrogators—at the exit(s) of a library read faster and with fewer false alarms.

They also have the potential to capture more information. When the exit sensors are not interfaced with the circulation database, but check only the theft digit that shows that an item is checked out or not checked out, the amount of information is no greater than with EM and RF systems. With a link to the circulation database, the exit sensors identify the items that actually left the library.

Patron self-discharging station

A patron self-charging station can be modified to also serve as a patron self-discharging station by adding a reader and bin for the returned items. A receipt printer is usually added as well.

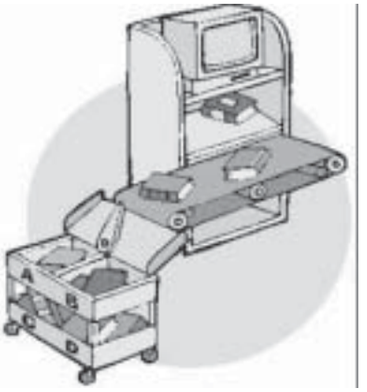
Bookdrop reader

Installing a reader in a bookdrop allows reading of the RFID tags as patrons drop off the items, which eliminates the labor-intensive steps of check-in and deactivation of the security protection by library staff. Books and other library materials can go directly to a sorting area.

Sorter

Libraries with large circulation volumes can eliminate the check-in and sorting of returned materials by combining a sorter with one or more bookdrop readers. The sorters include conveyers to move materials from the book return(s) to the sorter.

The sorter may have as few as two or as many as 200 bins. The two-bin sorter separates items to be reshelved from those to be placed on hold shelves. When more bins are used, the sort can be for areas of the library.



Portable reader

Inventorying and shelf-reading can be undertaken with a portable reader that need merely be passed in front of a shelf of books. The reader transmits the identification numbers to the server, which in turns sends it to the automated library system, and the response is returned in real time.

Alternately, the information may be batched and downloaded into a docking station. Some portable readers can accept downloads from an automated library system for checking against the shelves.

Servers

Not all RFID systems include a server. When a system is configured with one, it typically is a high-end PC or small enterprise server.

PC: personal computer

RFID standards

Although the International Organization for Standardization (ISO) has adopted a standard for the format and anti-collision specifications of 13.56 MHz passive RFID tags (ISO 15693-2), vendors have incorporated different proprietary protocols on top of the common 13.56 MHz frequency. Interoperability among the tags of different vendors will not be possible until a standard addresses RFID communications.

ISO has a working committee seeking to develop such a standard. When the standard is published as ISO 18000-3, tags conforming to the new standard will

be produced. The standard is expected to address both the air interface and anti-collision specifications. Publication may be as early as 2004.

The data structure and content of tags, however, won't change just because they can communicate with one another. One vendor's ISO tag may contain only an identification number, another's may contain author, title, and location as well as the identification number. The readers will read all of them, but the software of each vendor will need to be modified to look for differences in data structure and content.

The most useful RFID standard is SIP2, the protocol for interfacing an RFID system with an automated library system. It was initially developed as a de facto standard by 3M to interface its patron self-charging systems to automated library systems.

All major vendors, both library RFID and library automation vendors, have SIP2 conforming products. Some additional programming is required to interface a specific RFID system with a specific automated library system, but every RFID vendor commits that it will undertake that work for any automated library system that a customer is using.

The SIP2 protocol has its limitations. It is sequential in nature—you cannot check out a stack of books in one step using the protocol. The RFID reader may scan several books at a time and immediately check them out in a bulk mode, but it must communicate the information to the automated library system one transaction at a time. The interface between the RFID and automated library systems must be finely tuned or the process will slow down.

Additional information

Automatic Identification Manufacturers (AIM), www.aimglobal.org

For additional information about the technology of RFID, contact the Automatic Identification Manufacturers (AIM). This trade group addresses all types of identification technologies to provide detailed information about RFID, barcodes, magnetic stripes, optical character recognition, RF, and voice recognition.