

Radio-Frequency-Identification for Security and Media Circulation in Libraries

State of the art of modern radio frequency identification systems / description of system components / suitability of different systems / reference installations / costs

Abstract

Radio Frequency Identification (RFID) Systems have been in use in libraries for 5 years for book identification, for self checkout, for anti-theft control, for inventory control, and for sorting and conveying of library books and AV materials. These applications can lead to significant savings in labor costs, enhance customer service, lower book theft and provide a constant record update of media collections. In this paper the technical features of a modern RFID system are described to provide a guideline for the evaluation of different systems. The most important result is that non-proprietary systems can be used for libraries today since the new generation of RFID chips with the ISO standard 15693 is available. With this technology libraries are not dependent on one company for their lifeline.

1. Introduction

RFID Systems (RFID: Radio Frequency Identification) were developed about 30 years ago. They originally were niche products. They were used for "Radio Tracking" of wild and agricultural animals, and evolved later into a technology which is used in many industrial applications today [3]. For instance, all car keys of major car manufacturers contain a little transponder (sender) which sends a radio signal to the car steering wheel lock and to the car's electronics, resulting in a very efficient theft control. Also, RFID systems are used for building access control, e.g. with "smart cards" for identification at doors [1]. Another popular application is "Easy-Pass" used on toll highways and bridges.



With the development of flat and flexible transponders called smart labels, such systems became suitable for other applications, e.g. for collection management and security in libraries [4]. The deactivation for security was being rendered obsolete by libraries who automated integrated circulation systems based on RFID. Once libraries automated, they no longer used "date due" cards in book pockets which were manufactured with foil that would shield the radio frequency tag, therefore allowing the material to exit the library without setting off an alarm. Also electromagnetic strips (which could be repeatedly turned "on" and "off" by the library) were no longer used. The technology behind the first RFID library system was taken from electronic access control equipment. This is a type of door lock security system that only allows access to persons who present a proximity card to an RFID reader located next to a door frame. In turn this RFID reader is wired to a computer whose software determines access to various parts of a building. Hence "read only" RFID cards were used as a "license plate" type of identification of the person and in a library application the book or other media. Thus a modified electronic access control system was designed to turn the security alarm off and on in a book without library staff intervention or foil date due cards.

As the market developed "read/write" RFID labels became competitive in price to the "read only" labels that were used in first generation RFID library systems. Today 100'000 RFID labels with an ISO chip cost less than 0.55 US Dollar each. This allowed libraries to eliminate the parallel RFID network and additional server that was required for these first generation systems. We will elaborate on this latter in this paper. The actual development of the market, especially in Asia, shows that RFID Systems are used in about 20 million books. In the USA there are about 60 libraries with approximately 10 million books using this technology [5].



In this article the relevant technical basics of RFID technology will be explained, always pointing out the relevance to libraries. In addition there is a description of RFID library systems down to the most important components. Such a system is taken as an example from a company Bibliotheca Inc., RFID Library Systems [6]. There is a listing of technical criteria, which shall provide a guideline for the evaluation of RFID library systems. Finally there is a short report about three installations in Europe, the first University library in Leuven (Belgium), the second and third are the public libraries in Winterthur (Switzerland) and in Vienna (Austria).

2. Technology

An RFID System comprises two units, a transponder and a reader. The transponder is attached to the object or person to identify; whereas the reader is stationary, in most cases. Both units contain an antenna and a computer chip (chip) to send and receive radio waves and process the information, which is behind the signals (Fig. 1). The reader unit is connected to a computer and power supply.

The signals from the transponder are sent at a frequency of 13.56 MHz. This frequency is approved worldwide for RFID systems. The transponder does not contain a battery – it uses induction to receive energy. This is important to make it useable for a long term application. This feature makes it possible to use it in books and other material.

For the use in libraries, the transponder is designed as an **RFID Label**, which is comprised of four elements: the chip, the antenna on a foil, the cover paper or plastic label and the silicon liner.



Chips for RFID labels are available from various companies today such as: Philips Semiconductors, Infineon, Texas Instruments, etc. They vary in capabilities like memory capacity, size, read/write versus read only and the way they are affixed onto the antenna (bonding vs. flip chip). These factors are relevant for the library in terms of performance, usability and of course reliability.

For libraries the **reader** can have different designs, for example: two stationary antennas with a reading distance of 3 feet between the sensor gates, a paper-sheet size antenna on a desk-top reader with an approx. one foot reading distance. Another design is a hand held unit (wand) with a six-inch reading distance. The readers differ not only in terms of reading distance and size, but also in reading speed and the amount of tags which can be read simultaneously.

Basically, modern RFID Systems have the following capabilities:

- signals are sent through non metal materials (there is no line of sight necessary like with a barcode)
- many transponders can be read at the same time (e.g. a stack of books)
- Some specific information can be read from the transponder and also be programmed (e.g. the checked in or checked out status).

3. System Description

A library RFID-System can keep track of patron history, the life cycle of a book, and hence, enables the librarian to keep better inventory and keep better security control of his/her library which corresponds to the view of a librarian. The patron enters the library through a sensor gate. The Patron will normally go straight to the book shelf or the information counter. An OPAC (online public access computer) or a book return station is also available. After he has taken the book from the shelf he will go to the self check station. This station contains



an RFID Reader in the front platen. When the Patron card is waved on top of the platen, the patron is identified and the account is opened. The books are now put onto the platen; the information is read and the chip programmed to a different status, as being checked out. When these books are carried through the sensor gate at the exit there will be no alarm. The book numbers are stored on the account and a receipt is printed. This receipt also contains the due date for return, the data for late return, and some additional data (e.g. items on hold for the patron, etc.). For those patrons who do not want to use the self check station they can still go to the circulation desk like they did before.

As mentioned above, if the Patron goes through the sensor gates with books that are checked out, there will be no alarm. In case the item was not checked out, the alarm will sound and then a signal is transmitted to the information counter and/or a turnstile to block the exit. The item is identified by "barcode" as well as title and author.

The way the book is tracked using an RFID system. When the book first comes into the library, it will get a library number and be entered into the library data base. The RFID label will also bear the number, which is programmed into the chip. The RFID number is then linked to the data base. The book will then be put on the shelf and will now be active in the circulation system. The librarian can take inventory by means of a hand held reader (inventory wand). The reader is waved alongside the shelves and picks up all the individual signals from the books. It may also be used to find misplaced books

The basic advantages of a modern RFID System in a library can be summarized as following:

- No lines or greatly reduced lines at the check out counter.



- Less repetitive work (and repetitive stress injuries) for personnel and an increase in interaction with the patrons.
- The use of an RFID system increases the security function in a library
- Reduced material costs and handling (only one label instead of two or three).
- A regular inventory control and update of the data base is possible.
- Automation of sorting and conveying functions.
- The easy search for mis-shelved books.

4. Connection to the Management System Software

The implementation of an RFID system requires the connection to the circulation software system (also called the integrated library system (ILS) or Library Management System (LMS)) because certain data is delivered to the data base or is taken from it. The data exchange is based on a TCPIP protocol (SIP2, SLNP, also NCIP in the future). Most of the software companies offer such an interface. They also offer other options like statistics (number of visitors, checked out media) etc. This data exchange protocol to the circulation system should be checked when installing.

5. System Components

The RFID Library System consists, as described in section 3, of several components. The most important ones are: the sensor gate(s), the self check unit(s) and the staff station(s). These components are independent of each other and from the main software system (circulation system). Since the components are "intelligent", an additional server is not necessary as with first generation RFID library systems. These components allow for easy addition of components.

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High reading speed is possible with this concept, which is the transmission of important data directly from the chip. This availability of data in the book/media does not require time-consuming scrolling through the data base server. High reading speed is important for the sensor gate and the inventory wand.

Sensor Gate

The sensor gate was designed for the detection and reading of information from RFID labels, which are carried through a door. The gate supplies the media number that shows which books were stolen.

The reader consists of two or three antennas which are parallel to each other (Fig. 4), plus housing for the reader electronics. The antennas show a similar design like the sensor gates used in stores for theft control. The aisle width is 90 cm (35") with two antennas, and 1,8 m (70") with three antennas.

Self Check Unit

After the identification of the patron, which can be done with an RFID ID Card, a typical barcode library card, magnetic ID Card, or a PIN number, she can put the items (books, CDs, video tapes, etc.) onto the read surface in front of the self check unit to be registered under her name and programmed to "check out". The chip will be set on "quiet" mode, so as not to alarm at the exit.

It is possible to return books at the self check station. But most libraries prefer to have only one function to avoid any lines of waiting patrons. So the return function is an optional function as is looking up their account status. Multiple items can be checked out at the same time in a stack. The height of the read range is approximately 25 cm (10"). The thickness of the items, determines the number of items that can be checked out within the read range.



Staff and Conversion Station

To check out/in books at the staff station is a similar procedure like at the self check unit. There are additional software windows integrated into the LMS which allow other functions for the staff like "conversion", which is the initial programming of the chip, plus some controlling functions.

The dimensions of the staff station antenna are 240 x 340 x 9 mm (13" x 9" x 0.25"), which results in a very low profile design. It is connected to a personal computer. The antenna will be set beside the PC or underneath the counter. The Staff Station is modular consisting of the antenna, electronic module and the power supply. Ergonomics were paramount in the design of the BiblioChip® Staff Station and Self Check-out Station.

This station can also check out / -in a stack of materials (to 25 cm, 10" high) and hence, is a great time saver for the staff.

Inventory Wand

This device is basically used for various wireless functions: to take inventory, to locate specific types of books or media and to find misplaced items. Another function of this device is to feed data into the main system via a wireless LAN (network). Special library specific software programs can be written and utilized with the inventory wand. The Personal Data Terminal (PDA) utilizes Windows™ CE software.

Book Return Station

Many libraries require a separate book return station. The book will be identified at a RFID reader unit, located inside the book return slot, and then placed in a



bin. It will automatically check in books, take them off the patron's library account and reactivate the security function.

There are 3 options: The return at a

Self Check Station where the return function is activated (Check-Out plus Return or Return only). This can only be used inside the library.

Book Return Station without Sorting (inside the building, in a lobby room or at the outside wall for external access)

Book Return Station with Sorting (like above, but with sufficient space for a sorting equipment).

For sorting, two or more bins can be used, for sorting books on hold, media groups, etc. In a more sophisticated system the sorting can be expanded to numerous bins with the appropriate conveying equipment.

RFID Labels

The core of the system is the RFID label, which is marketed under the brand name of BiblioChip[®]. Apart from the chip, it contains a specially trimmed antenna in order to achieve the highest reading distance. The technology is open and underlies the new Standard ISO 15693 [2]. This standard guarantees that the chips which are used can be supplied from various sources and are compatible with each other, meaning "non-proprietary".

Non-Proprietary is an important requirement for modern libraries today; since they make long-term investments and cannot afford to be dependent on one company for their lifeline. In a worst case scenario, all the labels in a library of 100,000 books would have to be ripped out and replaced by a new version of chips.

More advantages of the new BiblioChip[®] labels are that they can be applied on all media, including CDs and DVDs. The read/write chips are attached to the label

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using a “flip chip” technology which allows a low profile (no bump) label; this makes a rugged RFID label that can survive book drop falls and the flexing of paper back books. Last but not least, they have a very high reading speed in order to be read at the exit sensor gate(s) or on the bookshelf.

The usability for all media material is possible due to two factors:

- A special design of the antennas makes it possible to put the labels directly onto CDs/DVD’s for Self Check. For security function an additional label is attached.
- Magnetic stripes labels are no longer necessary that would destroy the media with a “de-sensitizer” magnetic device. BiblioChips® are safe on all media.

5. Criteria for a Modern RFID Library System

The following criteria are relevant for the choice and comparison of RFID systems in libraries:

<ul style="list-style-type: none">• The functions mentioned in sections 3 and 4 are performed with a high reliability (reading in a sensor gate, self check, staff station, inventory control, return station)
<ul style="list-style-type: none">• The availability with compatible chips (RFID labels) must be guaranteed
<ul style="list-style-type: none">• Chip technology is compatible with different generations of RFID systems from different producers (ISO 15693 Standard)
<ul style="list-style-type: none">• Additional security strips are not necessary (no electro magnetic strips)

<ul style="list-style-type: none"> • The system can also be extended with ID-Cards, access control to a lobby room, payment at a copy machine, internet access, coffee machines etc.
<ul style="list-style-type: none"> • A support must be given by the installed management system software (circulation software), SIP2 is the standard today, NCIP upcoming
<ul style="list-style-type: none"> • All media is equipped with RFID labels (only exception: double sided DVDs)
<ul style="list-style-type: none"> • Additional servers are not required and the system components can be exchanged during operation of the library

6. Pricing and Reference Systems

It is difficult to get representative pricing structures, as the requirements vary significantly between the libraries. But the following estimation is possible: considering that the price for a label is 0,55 US Dollar at 100'000 pieces plus the additional equipment cost, a library of this size would have to invest about 150'000 US Dollar in total. However, it is possible to start with a small budget (like tagging the books only and do the stack reading at the counter) and add the further components at a later stage.

Amongst the 26 installations in Germany, Switzerland, Belgium, Netherlands, Austria, Israel and the US only three examples are presented here. They emphasize the economical considerations for the benefit of the system.

In **Leuven**, the biggest Belgian University library and the first University library in all of Europe (Katholieke Universiteit Leuven, Campus Library Arenberg) uses a Bibliotheca RFID system, in order to increase the efficiency and quantity of



media circulation. The library is open 14 hours a day throughout the week. The total book collection is 4.5 million.

The IT engineers of the KU Leuven were the first to program management software (LMS) for university libraries (Dobis/Libis). The Bibliotheca RFID system was chosen based on the layout, the staff and the architecture of the library. The collection comprises 18 departments in 2 facilities. At present, there are 100'000 media housed in a new library building. In the future this library will contain about 250'000 media for public access; additional 600'000 media are located in compact shelves. An automatic book sorting machine is planned.

In order for this library to function with a limited staff of 20 people, in two shifts, there was the necessity to use new technology for the self check of books. This means that only 3 - 4 staff people are present in the library at any one time. They are responsible for the management and adding of new media and of course assisting their patrons. The official opening of the building (designed by a Spanish star architect Rafael Moneo) has taken place on the first of October 2002.

In **Winterthur** (Switzerland) three libraries are working with RFID. The most recently opened public library holds a collection of about 250'000 items. The main reason to implement the RFID system was: the number of borrowed items was steadily increasing, especially with the new media like CDs and DVDs. In order to keep the number of staff at the same level and at the same time offer a much wider and more attractive collection the decision was clear: to use RFID in order to automate all possible work processes.

With the implementation of the RFID system the tasks of the librarians have changed: more and more younger people use the facilities and so the staff has to



take over a survey and social function – which leads to the necessity of a self issue station, in order to have time to look after the young visitors.

The library lobby can be accessed with an RFID ID-Card. In the lobby there are 4 book return stations available at 24h per day. In the next (inner) area 4 self issue stations are installed, plus 4 staff stations. All books and CDs are tagged with RFID. The RFID ID-Card also contains a chip with payment function, to be used at the coffee and copy machine. There are various plans for an extended use of the cards (e.g. internet access). The entrance to the inner area is secured with RFID gates.

The **Vienna** public library with an inventory of 300'000 items has opened in an entirely new building. 240'000 are books, being tagged with RFID labels, plus 60'000 CDs and DVDs, being tagged with special CD-RFID labels. The RFID system is of vital importance to the library: in order to be able to run the library with a limited number of well educated staff that in addition can attend visitors. The system comprises 13 staff stations, 11 gate antennas and 5 self check stations. Both the staff stations and self check stations work with stack reading. 3'500 visitors per day use the system.

7. Conclusion

Libraries have become a driving force in the development of RFID for the mass market. This technology was first used in other sectors of the industry, such as logistics, airline luggage automation or parcel distribution. The leading role for libraries seems to be understandable, since libraries share their knowledge in the development of these systems and also the benefits have been greatest in the library community. It is important to know that the software was developed in an



earlier stage and is today far more refined. It is also very interesting that in countries with low labor costs these systems are also becoming popular (e.g. India, Korea, Singapore).

Finally, the library market also benefits from the current development (and expectations) in other markets; the prices have dropped to a level, where the curve is more or less stable because higher production numbers (several 100 Mio Chips) were reached in 2003. The production capacities for RFID labels have been calculated accordingly to serve a multi-million unit market – and in recent years the prices for RFID labels have dropped more than 1/2. With this background knowledge, it is obviously important to choose a technology which relies on the ISO 15693 standard.

8. References

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