RADIO FREQUENCY IDENTIFICATION IN LIBRARIES

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Radio Frequency Identification (RFID) systems have been in use in libraries for five years for book identification, for self checkout, for antitheft control, for inventory control, and for the sorting and conveying of library books and AV materials. These applications can lead to significant savings in staff costs, enhance service, lower book theft and provide a constant update of media collections. The technical features of a modern RFID system are described to provide a guideline for the evaluation of different systems. The most important issue is that nonproprietary systems can be used by libraries today because the new generation of RFID chips with the ISO standard 15693 is available. With this technology, libraries are not tied to one company. Edited version of 'Radio frequency identification systems for libraries and archives: an introduction' published in 'Library and archival security' 18(2) pp7-21 ©2003, Haworth Press Inc

Radio Frequency Identification (RFID) systems were developed about 30 years ago. Originally they were niche products. They were used for radio tracking of wild and farmed animals, and evolved into a technology which is used in many industrial applications.[1] For instance, car keys of major car manufacturers contain a little transponder or sender which sends a radio signal to the car steering wheel lock and to the car's electronics, resulting in very efficient theft control. Also, RFID systems are used for building access control eg with smart cards for identification at doors.[2] Another popular application is E-ZPass, used on toll highways and bridges.

With the development of flat and flexible transponders called smart labels, such systems became suitable for other applications eg for collection management and security in libraries.[3] The deactivation for security was being rendered obsolete by libraries which 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.

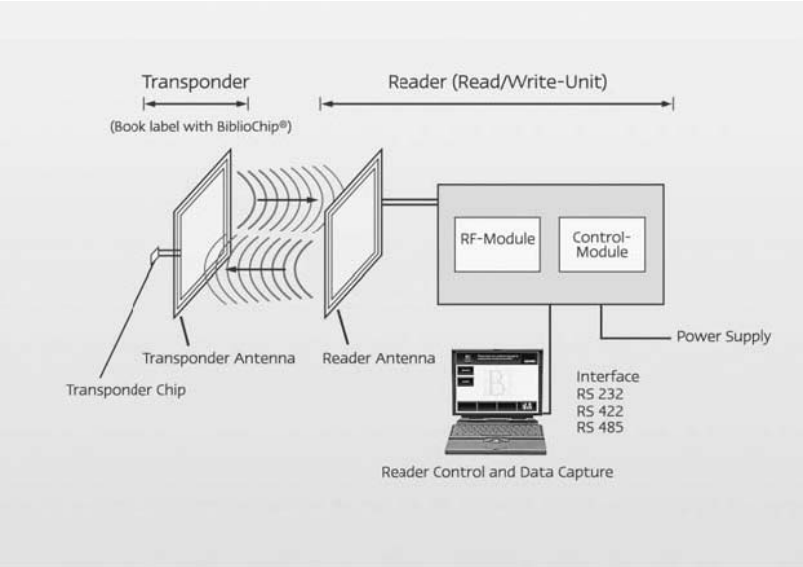
As the market developed, read/write RFID labels became competitive in price to the read only labels that were used in first generation RFID library systems. Today 100,000 RFID labels with an ISO chip cost less than US$0.55 each. This allows libraries to eliminate the parallel RFID network and additional server required for these first generation systems. The actual development of the market, especially in Asia, shows that RFID systems are used in about 20 million books. In the US, there are about 60 libraries with approximately 10 million books using this technology.[4]

In this article the technical basics of RFID technology will be explained, 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.[5] There is a listing of technical criteria which provides for the evaluation of RFID library systems. Finally, there is a short report about three installations in Europe.

Technology

An RFID system has 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 to send and receive radio waves and process the information, which is behind the signals (figure1).

Figure 1



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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, using induction to receive energy. This is important to make it useable for a longterm application, a feature which 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 has 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 companies such as Philips Semiconductors, Infineon, and Texas Instruments. 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 one metre between the sensor gates, or a paper sheet size antenna on a desktop reader with an approximate 300mm reading distance.

Another design is a handheld unit or wand with a 150mm 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 nonmetal materials. There is no line of sight necessary as with a barcode
- many transponders can be read at the same time eg a stack of books
- some specific information can be read from the transponder and also be programmed eg the checked in or checked out status

System description

A library RFID system can keep track of user history, the life cycle of a book, and hence enables the librarian to keep better inventory and better security control of the library (figure 2, figure 3).

Figure 2 shows how the user enters the library through a sensor gate. The entrance and exit gates are separated in this picture, but can also be combined. The user will normally go straight to the bookshelf or the information counter. An opac or a book return station is also available. After they have taken the book from the shelf

they will go to the selfcheck station. This contains an RFID reader in the front platen. When the user card is waved on top of the platen, the user 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 date for return, the data for late return, and some additional data eg items on hold. For those users who do not want to use the selfcheck station, they can still go to the circulation desk.

As mentioned above, if the user 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.

Figure 3 shows 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 database. The RFID label will also bear the number which is programmed into the chip. The RFID number is then linked to the database.

The book will be put on the shelf and will now be active in the circulation system. Inventory can be taken by means of a hand held reader (inventory wand). The user is waved alongside the shelves and picks up all the individual signals from the books. It may also be used to find misplaced books.

Figure 2

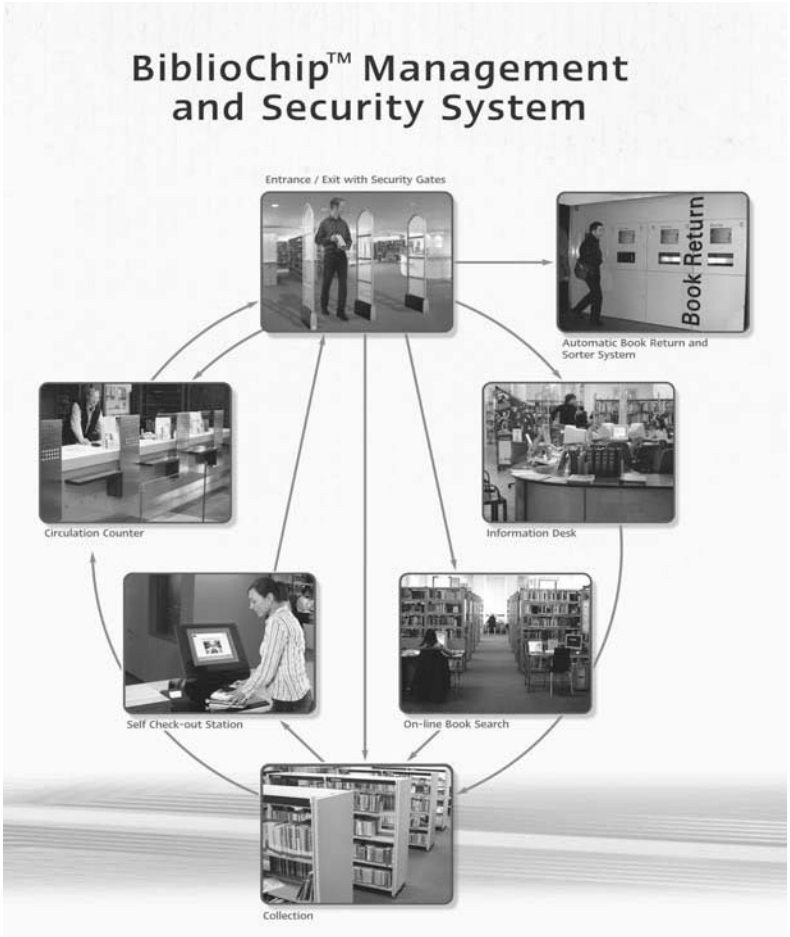

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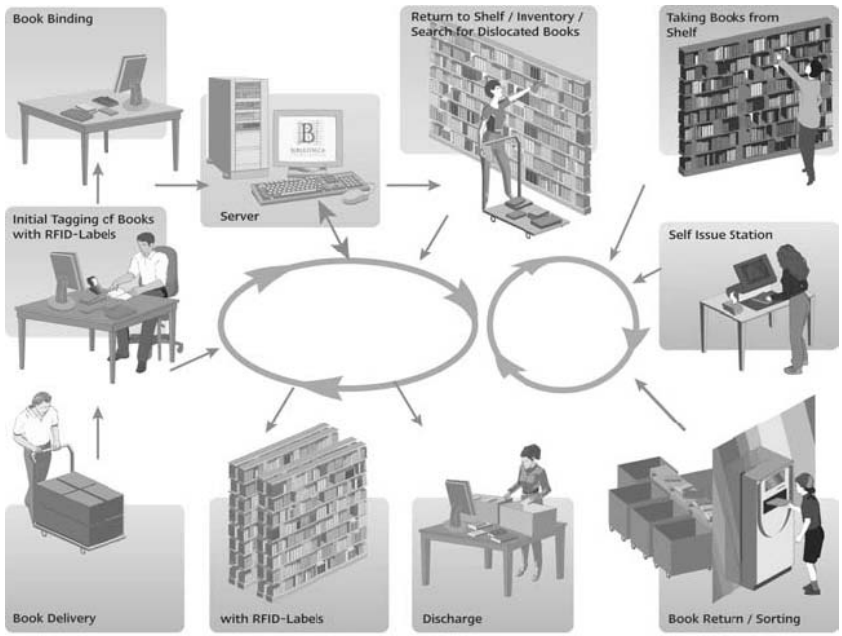
Figure 3



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The basic advantages of a modern RFID system in a library are

- no queues or greatly reduced queues at the checkout counter
- less repetitive work and repetitive strain injuries for staff and an increase in interaction with the users.
- 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 database is possible
- automation of sorting and conveying functions
- the easy search for misshelved books

Connection to the management system software

An RFID system requires connection to the circulation software system because certain data is delivered to the database 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 visitor statistics, and checked out items. The data exchange protocol for the circulation system should be checked when installing.

System components

The RFID system, as described in figure 3, consists of several components. The most important are the sensor gates, the selfcheck units and the staff stations. These components are independent of each other and form the main software or 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. 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 database 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 (figure 4), plus housing for the reader electronics (not shown in figure 4). The antennas show a similar design to the sensor gates used in stores for theft control. The aisle

Figure 4

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Figure 5

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width is 90cm with two antennas, and 1.8m with three antennas.

Selfcheck unit

After the identification of the user, which can be done with an RFID ID Card, a typical bar code library card, magnetic ID Card, or a PIN number, they can put the items (books, cds, videos etc) onto the read surface in front of the self check unit to be registered under their name and programmed to check out (figure 5).

The chip will be set on quiet mode, so as not to alarm at the exit.

It is possible to return books at the selfcheck station, but most libraries prefer to have only one function to avoid any user queues. So the return function is an optional function, as is looking up user 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. 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 procedure similar to the one at the self check

unit. There are additional software windows integrated into the LMS which allow other functions for the staff, such as conversion, the initial programming of the chip, plus some controlling functions. The dimensions of the staff station antenna are 240x340x9mm, which results in a very low profile design. It is connected to a personal computer (figure 6).

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

Inventory wand

This device (figure 7) 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.

Figure 6

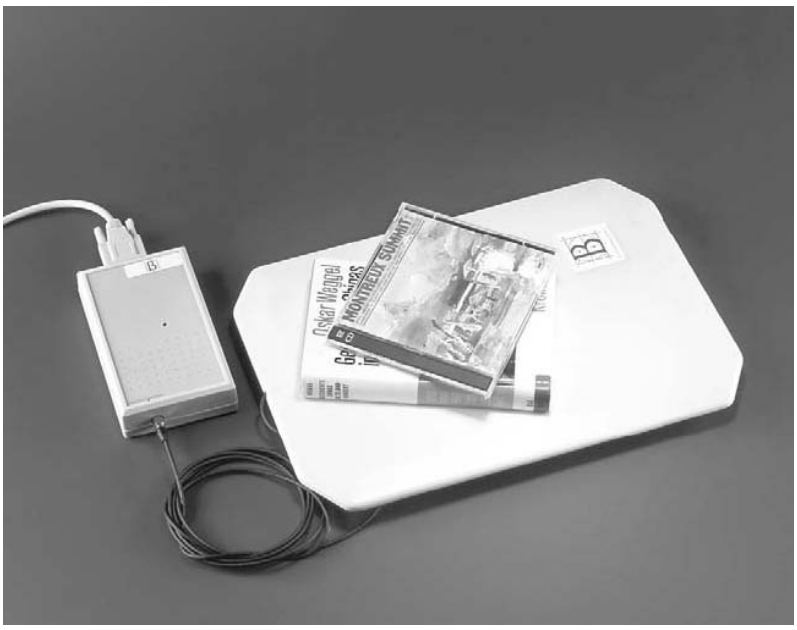

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Figure 7

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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 user's library account, and reactivate the security function.

There are three options. The return at a

- selfcheck 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, as above, but with sufficient space for a sorting equipment

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.[6] This standard guarantees that the chips which are used can be supplied from various sources and are compatible with each other, meaning that they are nonproprietary.

Nonproprietary is an important requirement for modern libraries today, because they make longterm 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 using a flip chip technology which allows a low profile, no bump, label. This makes a rugged RFID label that can survive bookdrop falls and the flexing of paperbacks. 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/dvds for selfcheck. As a security function an additional label is attached
- magnetic stripes labels are no longer necessary that would destroy the media with a desensitizer magnetic device. Biblio-Chips™ are safe on all media

Criteria for a modern RFID library system
The following criteria are relevant for the choice and comparison of RFID systems in libraries

•	The functions mentioned in sections 3 and 4 are performed with high reliability (reading in a sensor gate, selfcheck, staff station, inventory control, return station)
•	The availability with compatible chips (RFID labels) must be guaranteed
•	Chip technology is compatible with different generations of RFID systems from different producers (ISO 15693 Standard)
•	Additional security strips are not necessary (no electromagnetic strips)
•	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
•	Support must be given by the installed management system software (circulation software), SIP2 is the standard today, NCIP is upcoming
•	All media is equipped with RFID labels (only exception is double sided dvds)
•	Additional servers are not required and the system components can be exchanged during operation of the library

Pricing and reference systems
It is difficult to get representative pricing structures, as the requirements vary significantly between the libraries. The following estimation is possible. Allowing for a label cost of US$0.55 at 100,000 pieces plus the additional equipment cost, a library of this size would have to invest about US$150,000 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.

From the 26 installations in Germany, Switzerland, Belgium, Netherlands, Austria, Israel and the US only three examples are pre-

sented here. They emphasize the economic issues and benefits of the system.

In *Leuven*, the biggest Belgian university library uses a Bibliotheca RFID system. The library is open 14 hours a day throughout the week. The total book collection is 4.5 million.

The IT engineers at 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; an 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 selfcheck of books. This means that only three to four staff people are present in the library at any one time. They are responsible for the management, adding of new resources and, of course, assisting users.

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 that 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 made to use RFID 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 which has led to the need for a selfcheck station, in order for staff to have time to look after these young users.

The library lobby can be accessed with an RFID ID card. In the lobby there are four book return stations available 24 hours per day. In the next (inner) area, four 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 eg internet access. The entrance to the inner area is secured with RFID gates.

The *Vienna* public library, with 300,000 items, has opened in an entirely new building. There are 240,000 books being tagged with RFID labels, plus 60,000 cds and dvds being tagged with special RFID cd labels. The system is of vital importance to the library in order to be able to run with a limited number of well educated staff, that, in addition, can attend to user needs. The system comprises 13 staff stations, 11 gate antennas, and 5 selfcheck stations. Both the staff stations and selfcheck stations work with stack reading. The system is used by 3,500 people daily.

Conclusion

Libraries have become a driving force in the development of RFID for the mass market. This technology was first used in other sectors, such as logistics, airline luggage automation and parcel distribution. The leading role for libraries is understandable, since libraries share their knowledge in the development of these systems. Also, the benefits have been greatest in the library community. It is important to know that the software is far more refined today. It is also very interesting that in countries with lower labor costs, these systems are also becoming popular eg India, Korea, and Singapore.

Finally, the library market also benefits from 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 were reached in 2003. The production capacities for RFID labels have been calculated accordingly to serve a multimillion unit market. In recent years the prices for RFID labels have dropped by more than one half. With this background knowledge, it is obviously important to choose a technology which relies on the ISO 15693 standard.

Bibliotheca RFID Librarys Systems AG of Switzerland is a leading company in RFID technology with a wholly owned subsidiary, Bibliotheca Inc, based in Yardely, PA USA. The company specializes in designing, producing and marketing of RFID systems, hard and software for library automation and media security. It is Europe's major RFID library system with over 40 installations in major public and university libraries worldwide. These include libraries in New York State, such as the Mastics-Moriches-Library, Long Island, the Fayetteville Public Library, Syracuse and in Pennsylvania, the Northland Public Library, Pittsburgh. Installations in Canada at the Toronto Richmond Hill Public Library and in Vienna, Stuttgart and Leuven are further well known sites.

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