RADIO FREQUENCY TECHNOLOGY IN LIBRARIES

Corina POP, Gabriela MAILAT
Transilvania University of Brasov, Romania

Abstract. Modern libraries have undergone significant changes in the process of introducing advanced computer and communication technologies. RFID (Radio Frequency Identification) systems were adopted by many libraries in the last years due to their advantages in comparison with barcodes. One most important advantage consists in the increased amount of information that can be stored and processed for specific purposes. Libraries use RFID systems for book identification, self-checkout, antitheft control, inventory, book circulation. All these contribute to more efficient library services in terms of reduced labour costs, better document management and collection record.

Keywords: barcode, RFID, library

¶

1. Introduction

The RFID (**R**adio **F**requency **ID**entification) systems are a specific class of wireless communication systems used in data identification processing and storage with minimum human intervention, even in adverse environment conditions.

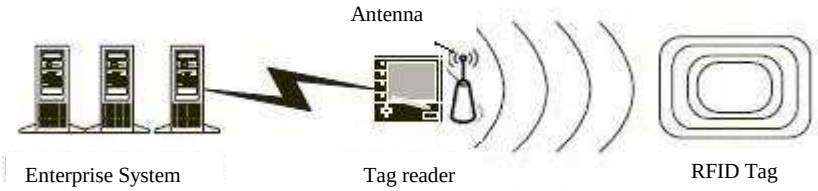


Figure 1. A typical RFID system

RFID systems and technologies come in a wide variety of versions depending on the specific field of application. There are differences between these system versions in terms of the information amount that can be detected, read and transmitted, the effective operating range of the system, the operating frequency band, the size of system components and its overall cost.

In terms of structure, all RFID system versions contain the same essential components, the RFID tag, which is attached to the object or item and the reader which alongside with the antenna forms an RFID station.

The RFID station is connected to a computer system or server for processing the data transferred from the RFID tag. The RFID station is capable of reading tags individually or even groups of tags even if these are not visible due to the way they are attached to an item or a document. The electronic support (chip) of a tag is capable of storing large amounts of data enabling precise identification of the considered item. In the case of books, an RFID tag, can store more additional information along with its inventory number and title.

1.1. The rationale of introducing RFID

RFID systems have a series of advantages when compared to the barcode technology. These advantages are determined by the characteristics of the wireless technology that allows better versatility and higher performances compared to traditional barcode systems.

The advantages can be summarized as follows:

- RFID systems provide complete information on the item;
- Permanent information updating;
- High-speed processing of increased data amounts even for moving objects;
- Enhanced object security;

- Reduced human intervention through process automation.

This paper intends to provide a comparative presentation of benefits and opportunities upon introducing RFID systems in libraries.

2. RFID system operation

As was shown before, the basic structure of an RFID system includes the item tags, readers and the computer system of the application [1, 3].

The communication link between readers and tags is assured via electromagnetic waves (wireless). This allows the system to detect and read the information stored on a number of tags Most RFID applications use so-called passive tags which are powered by the electromagnetic field generated by the reader [5, 6].

The communication between reader and tag occurs during a time window containing three sequences. In the first sequence, the reader transmits a continuous wave to the tags. This electromagnetic field both activates the tags and provides them with the necessary energy for receiving the reader commands. During the second sequence, the command is transmitted to the tags. In the last sequence, the reader transmits a continuous wave to the tags. The tags modulate this wave and backscatter it to the reader. Between two communication windows is a transaction break during which radiofrequency transmission is interrupted [2, 3].

The power levels of radiofrequency signals and the allowed frequency bands are object to various institutional regulations and standards such as the European Telecommunications Standard Institute (ETSI), Federal Communication Commission USA (FCC) as well as the ISO norms (International Organisation for Standardisation) [4].

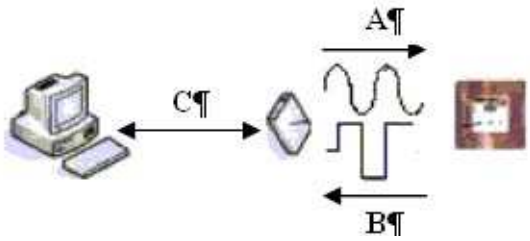


Figure 2. RFID system operation

Communication between reader and tag is optimum if the strength of the electromagnetic field is sufficiently high to enable tag activation. At the same time, specific frequency bands are used depending on the type of application.

The different types of applications can be classed depending on the effective operating range of reader-to-tag communication.

For this purpose, three frequency bands were defined for covering the whole area of applications using RFID systems. Thus, short-range RFID applications use the low frequency band, medium range RFID systems operate in the medium frequency band while long-range RFID systems operate in the high frequency band. Library RFID systems are designed to ensure medium range communications and operate at 13.56 MHz.

3. RFID systems in libraries

The permanent diversification of library services determines the libraries to introduce the new IT technologies in order to reduce costs and increase the level of automation.

In the early 1990's a new technology, the RFID system began to be adopted by libraries, to improve the inventory, circulation and security function.

While there are some similarities with the barcode technology e.g. the use of coded information labels for data transfer to central server, the most important difference consists in the capability of RFID reader to scan the tags in the absence of a direct visual line, through different materials, such as book covers and DVD cases.

Nevertheless, RFID systems provide many

additional features capable for improving library services and processes. For instance, the tags contain memory chips for storing amounts of data for beyond the capability of a barcode tag.

Apart from the ISBN, these can provide very useful information on borrowing/return dates, classification codes but also comments and book evaluations which can help users with their choice.

After comparing the main characteristics of RFID systems with traditional barcode systems a series of clear advantages of the former will result (Table 1).

Table 1. Advantages of RFID compared to barcode

RFID	Barcode
The information ca be both read and processed	Read-only technology
Allows tag reading through most materials	Requires direct line of sight
The information stored on tag amounts to several k-bytes	Only up to 13 bit can be stored
Allows simultaneous reading of tens of tags (anti-collision system)	Reads only one item at a time
Enables data encryption (high security level)	Barcodes can be read without restriction
Long service life– minimum 10 years	Service life limited by print quality
Fast check-up of shelved books(up to 30 times faster compared to barcode)	Slow book check-up requiring book removal from shelf
RFID tags can be electronically deactivated (put into latency)	Barcodes can only be physically destroyed

In order to include as many library services as possible and making them more efficient, libraries are ready and prepared to implement more advanced IT technologies, to reduce the costs entailed by routine activities and to intensify and extend the process of library automation [7].

RFID systems are related to barcode technology by employing encoded tags in order to communicate information about a specific object (e.g. book or DVD in a library) to a control server.

The main difference consists in the fact that RFID uses radio frequencies for information transfer between tags attached to items (as book in libraries) which are generated by the RFID reader instead of using laser readers like in barcode systems.

Even more importantly, the implementation of new technologies will provide the libraries with new types of data and information that will radically improve library services quality and efficiency.

The presence of memory chips on RFID tags with storing capacities of tens of bits up to kilobytes which is far superior to the barcode storing capacity, devised for the book's ID only, allows for storing additional data about the book such as:

- The ISBN;
- Book demand frequency;
- Recent data about circulation;
- Classification codes;
- Evaluation data, etc.

This additional information can be used for extending and diversifying library services. The users are informed about the lending frequency of a certain book while the library can provide useful information on the opportunity of choosing a certain book.

RFID operations are based on automatic equipments for efficient and fast handling and processing of a great number of books and require very little assistance from library staff. Considering also that many operations can be accomplished by the users through self-service, the number of library staff involved in these operations can be significantly reduced.

On the other hand, RFID systems provide major advantages for libraries and librarians by significantly reducing inventory time, check-in/ check-out of books and security functions. The time efficiency in this respect is very high, of about 20 to 30 times, as was experienced in some libraries.

3.1. The inventory process

With RFID tags attached to be entire book collection, inventory operations can be performed using portable, easy-to-use, devices that are passed alongside the shelved books. This procedure occurs effortlessly, the books do not need to be touched or moved.

Some thousands of books may be processed every hour compared to the traditional time-consuming way.

In terms of locating lost of missing items, RFID systems are very useful and cost-effective.

3.2. Library checkout

The advantages of RFID – systems to identify and read signals from book ID tags are obvious and of great interest for circulation processes.

Whole book batches can be processed at

once during check-out compared with individual handling for barcode systems.

Self-checkout can be accomplished by users more easily, thus reducing the waiting times and crowding at the check-out counters.

Physical effort and stress of library staff and users are thus reduced to a minimum as could be demonstrated.

In addition, RFID implementation in libraries will in general result in:

-lesser crowded information counters;

-better quality of services for users

-reduction of professional diseases and accidents among library staff

3.3. Library check-in

Similar benefits are resulting from automated check-in procedures.

This is demonstrated by the system's capability of simultaneous check-in of several books but also by the possibility of books being checked in as they are passed through the slots of book return machines.

When combining the RFID-system with an AMH (Automated Materials Handling) system, the check-in procedures can be further enhanced.

The books are placed on a conveyor belt which passes in front of an RFID reader.

The necessary validation for check-in is performed by the RFID station and during the following sequence, the books are automatically sorted into categories and placed in containers. The final sorting operation is assured by the library staff which performs the required corrections and adjustments, before returning the books to the assigned shelves. Time saving was up to 80% as was reported by libraries.

3.4. Item Security

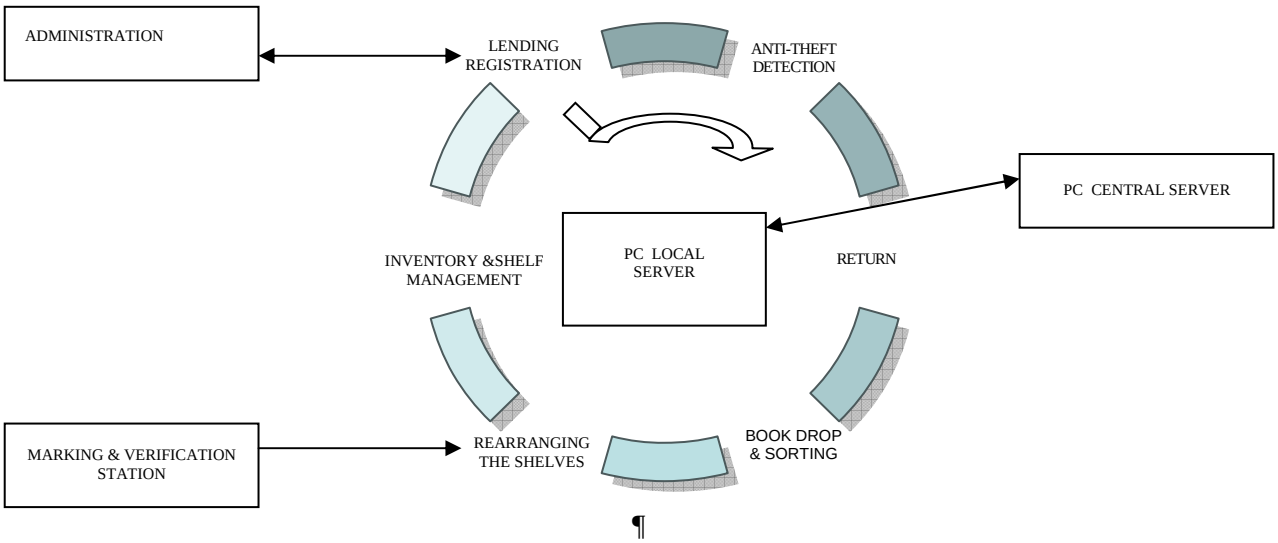
In terms of book security (antitheft protection) the benefits of RFID-systems are very high.

Book tags contain theft detection data that will be deactivated only after proper checkout procedures. Therefore, books can be passed through a RFID-monitored security gate without triggering an alarm signal.

Antitheft information is reactivated during book return procedures.

3.5. System description

The RFID-system entails important investments for its implementation in a library. Installing the system components for effective operation requires re-thinking of the users' routes starting at the security gate and all the way to the shelves or the information counter. Upon choosing a book from the shelf, the user will walk across the self-check station. On placing his card near the reading area, the machine will perform the identification of the card holder. Then the user will have to place the borrowed books near the reading area which will result in reprogramming the tag chips so as to enable book check-out. The books are uploaded into the user's account and the exit alarm is deactivated [8, 9].



¶

Figure 3. Library RFID Management System

Information regarding the circulation of items from a collection is monitored with the help of a bibliographic database. For RFID systems, the tags are provided with at least one barcode. There is no constant relation between author, title and barcode. Some vendors suggest the storage of additional data such as shelf location, date of last check-out, followed by author and title. The check –out can also be performed by the information desk staff if the user refuses to pass the self-check station.

Either way, the RFID system reads the tag and the book status will be changed accordingly in the bibliographic database. At check-in, the tag is read again and the database is once more updated.

4. Case Study – University of Bergen Library, Norway

This case study is the result of the authors' mobility period at the University of Bergen Library in the frame of Leonardo da Vinci – Procedure A - Mobilities Project RO/2005/95006/EX – 2005-2006 – "Migration, Emulation and Durable Encoding" – Forming experts in document management software, backup and restoration of documents, techniques for emulation programming and XML text format with application on old and rare books 01-14.Sept. 2006

In August 2005, the University Library at the University of Bergen, Norway was modernized and reopened as the Arts and Humanities Library. On this occasion, it has implemented the RFID system as a new technology for:

- enhanced book security and
- circulation.

This system allows users to find and select the books by themselves with the support of specific equipments for book manipulation.

New organisational solutions were applied to simplify document handling. The main objective was to create a differentiated service where the users were given the best possibilities for self service.

The adopted and implemented RFID (Radio Frequency Identification) system was the best option for this purpose. Currently, most operations, in terms of books circulation, are handled by this system.

RFID tags were fitted in every book enabling simple and rapid access to desired books, automated book return and sorting and location of misplaced books on shelves.

The system also provides antitheft alarm function, thus significantly increasing book security.

Structural conversions of the library spaces and equipment were also necessary, especially for fitting in the book return machines which had to be integrated in the existing furniture and equipment pieces.

After renovation, new spaces were created, allowing for more spaces, as was necessary for an open library.

The user flow had to be adapted to the new structure in order to optimize access to books.

One of the issues that had to be resolved was the type and material of the book shelves; the metal ones were replaced by wooden shelves in order to allow for flawless operation of the RFID system.

With the RFID technology implemented alongside with the new structural and organisational changes, the life of the library was definitely marked by the today's digital reality, with all its benefits and concerns offered to both librarians and library users [10].

Figure 4. Book return automat
The front, where books are returned

Figure 5. Behind the wall
Transportation line with automatic sorting of books

5. Conclusion

Based on the general characteristics and performances of the RFID system and after accomplishing the analysis of the advantages and implications generated by the new system in comparison with the traditional barcode technology, a number of practical issues can be stated. It is clear that introducing the RFID system in a library will require some major structural and functional modifications to allow maximum operating efficiency in all of the library's activities. If these changes become real, the benefits resulting from increasing the performance of library activities can be stated as follows:

- A significant reduction of the time required by specific library activities (inventory, circulation). The time taken by the check-in/check-out process will also decrease for both library staff as well as the user's waiting time at the information counter.
- A major reduction of routine activities and contacts between staff and users. The users will be able to accomplish some procedures all by themselves.
- A significant increase of book security status through specific tag-implemented devices which provide permanent item control. A book status can be thus checked at any instant.
- Simple location and direct access to any book, regardless of its loction on the shelf. This operation can be accomplished by using a portable reading device.
- A major cutting of costs in terms of materials handling.

All these positive aspects which contribute to an improved quality of library services are obtained by introducing new equipments for automatic control and sorting of books and reorganizing the user's routes. In addition, a direct consequence of this is the need for reducing and retraining the staff. However, regardless of whatever consequences and difficulties, the RFID technology cannot be ignored by the libraries in their continuous evolution.

References

1. Finkenzeller, K.: *RFID Handbook*. 2nd Edition. John Wiley & Sons Inc., ISBN: 0-470-84402-7, West Sussex, UK, 2003
2. Penttilä, K., Engels, D., Kivikoski, M.: *Radio frequency identification in supply chain management*. Journal of Robotics and Automation, Vol. 19, No. 3, 2004, p. 143−152, ISSN 0826-8185, Acta Press, Zurich, Switzerland
3. Penttilä, K., Aarinen, R., Sydänheimo, L., Kivikoski, M.: *The evolution of a wireless RFID and a cell phone.* Proceedings of IEEE International Symposium on Communication Systems, Networks and Signal Processing, p. 341–344, July 2004, Newcastle, UK
4. Penttilä, K., Keskilammi, M., Sydänheimo, L., Kivikoski, M.: *Radio frequency technology for automated manufacturing and logistics control. Part 2: RFID antenna utilisation in industrial applications.* International Journal of Advanced Manufacturing and Technology, Vol. 31, No. 1-2, November 2006, p. 116–124, ISSN 0268-3768, Springer London, UK
5. Finkenzeller, K.: *RFID Handbook: Fundamentals and Applications in Contactless Smart Cards and Identification*. Wiley, ISBN 0-470-84402-7, Hoboken, NJ, USA, 2003
6. Ahson, S., Ilyas, M.: *RFID handbook: applications, technology, security, and privacy*. Taylor & Francis – CRC Press, ISBN 978-1-4200-5499-6, Boca Raton, Florida, USA, 2008
7. Boss, R.W.: *RFID technology for libraries*. Available at: http://www.ala.org/ala/mgrps/divs/pla/plapublications/platechnotes/RFID-2007.pdf. Accessed: 2009–09–23
8. *** : *Libramation*. *Overview of library RFID products*. 2004. Available at: http://www.libramation.com/prod_radio.html. Accessed: 2008–05–08
9. ***: http://www.tagsysrfid.com Accessed: 2009-10-11
10. Bagge, B.A.: *Modern technology – modern library premises*. Available at: https://bora.uib.no/bitstream/1956/1823/1/Bagge.pdf Accessed: 2009-10-09