The State of RFID Applications in Libraries

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The adoption of Radio Frequency Identification (RFID) technology by libraries promises a solution that could make it possible to inventory hundreds of thousands of items in their collections in days instead of months. In addition, it would allow patrons to check out and return library property automatically at any time of the day. Besides speeding up checkouts, keeping collections in better order, and alleviating repetitive strain injuries among librarians, RFID promises to provide a better control on theft, nonreturns, and misfiling of a library's assets. With an estimated 35 million library items tagged worldwide in more than three hundred libraries, this technology is generating ever-increasing interest. In October and November 2004, the industrial technology department and the Robert E. Kennedy Library at Cal Poly State University, San Luis Obispo, surveyed participating libraries, RFID electronic discussion groups, and Library and Information Technology Association (LITA-L) electronic discussion group subscribers to collect information with regards to the implementation of RFID systems in libraries. Opinions were gathered regarding such topics, actual or estimated, as RFID implementation costs and time; the impact of the technology on operations such as handling of volumes and security; and RFID system features adopted such as conversion stations, self-checkout units, and security systems. Information on the various RFID library components and the results from the survey are presented in this paper.

As libraries adopt the use of tiny radio frequency identification (RFID) tags for tracking their assets, it is becoming possible to inventory hundreds of thousands of items in their collections in days instead of months and to allow patrons to checkout and return library property automatically at any time of day. In 1998, RFID was proposed as a way to make possible the self-serve processing of books and media by patrons in North America. It was initially installed in the library of Rockefeller University in New York in 1999. The first public library to use the technology was the Farmington Community Library in Michigan, also in 1999.[1] Since then, more than three hundred libraries have, or are in the process of implementing, an RFID system.[2] According to the research service *RFID Knowledgebase*, United States libraries lead the world in RFID use, with the United Kingdom and Japan tied for second place. It estimates that 35 million library items have been tagged worldwide.[3] Even the high-profile Vatican library in Rome has recently started tagging 120,000 volumes of its collection.[4] It is estimated that it will take the administrators at the Vatican library only half a day to inventory these tagged volumes as compared to the one month required prior to tagging. Tagging two million of the Vatican's forty-million-piece collection during the next few years is also planned.

Besides speeding up checkouts, keeping collections in better order, and alleviating repetitive strain injuries among librarians, RFID promises to provide better control against theft, nonreturns, and misfiling of a library's assets. San Francisco Public Library, after consulting with experts and other libraries, expects RFID to help reduce workplace injuries that cost it $265,000 in workers' compensation claims over the past three years.[5] At its present stage of development, RFID technology for libraries faces a number of unresolved issues. Among the most significant are privacy, lack of standardization, and cost. The Infopeople Project and the Information Technology Section of the California Library Association (CLA) conducted a recent survey. Of the approximately 51 percent of libraries who participated in the survey and were not considering implementing RFID, 58 percent cited cost as the major issue and 9 percent listed privacy concerns.[6] Molnar and Wagner have discovered several serious vulnerabilities related to a library patron's privacy, including a lack of appropriate access control, the shortcomings in the collision-avoidance protocols in place today, and poor key management practices.[7]

From October 13, 2004, to November 1, 2004, the industrial technology department and the Robert E. Kennedy Library at California Polytechnic State University, San Luis Obispo (Cal Poly), surveyed participating libraries, RFID electronic discussion groups, and Library and Information Technology Association electronic discussion group (LITA-L) subscribers to collect information regarding the implementation of RFID systems in libraries. The need to conduct a survey arose from the lack of information regarding the present state of RFID applications in libraries, and because the authors felt it was necessary to have the opinion of those directly affected by this technology. Members and subscribers were given a link directing them to an Internet-based survey. Twenty-nine libraries participated and completed the survey; of these, ten had already converted to an RFID-based system at their location. The survey provided an insight into library RFID systems. Opinions were gathered regarding such topics as RFID implementation costs and time; the impact of the

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technology on operations such as handling of volumes and security; and RFID system features adopted (e.g., conversion stations, self-checkout units, and security systems). Results from this survey are presented at the end of this paper.

RFID basics

An RFID system (figure 1) consists of three parts:

- A scanning device
- A transceiver with a decoder to interpret the data
- A transponder—the radio-frequency tag—that has been programmed with information

A scanning antenna puts out radio-frequency (RF) signals in a relatively short range. The RF radiation does two things; it provides a means of communicating with the transponder tag (the RFID chip) and it provides the RFID device with the energy to communicate. RFID tags for library applications do not need to contain batteries and can therefore remain usable for very long periods of time. Scanning antennas can be permanently affixed to a surface or can be in handheld form. An institution could build them into a doorframe to accept data from persons or objects (or in the case of libraries, books) passing through. Various RFID system components for library use will be discussed in this paper.

When an RFID tag passes through the field of the scanning antenna, it detects the activation signal from the antenna. This "wakes up" the RFID tag, and it transmits the information on its microchip to be picked up by the scanning antenna. The RFID tag may be one of two types. Active RFID tags have their own power source, the advantage of which is that the reader can be much farther away and still receive the signal. Although some tags are built to have up to a ten-year life span, their actual life span is more limited. Passive RFID tags, however, do not require batteries, can be much smaller, and have a virtually unlimited life span. Due to their lower costs and their ability to carry large amounts of information, passive RFID tags are being used for library applications.

Figure 2 shows a typical RFID tag to be applied to the books at a library. Besides carrying a unique ID number programmed by the library, these tags also carry a security bit that is activated when an item is returned to the library, and inactivated upon proper checkout. These actions are performed during a normal checkout or return operation and do not require a separate step as with magnetic-strip-type security devices,

thereby combining both inventory and security features. Figure 3 depicts a typical flow of information between the items—whether books or audio-video media—and the integrated library system (ILS).

RFID tags can be read in a wide variety of circumstances in which barcodes or other optically read technologies are useless. The tag need not be on the surface of the object (and is therefore not subject to wear), the
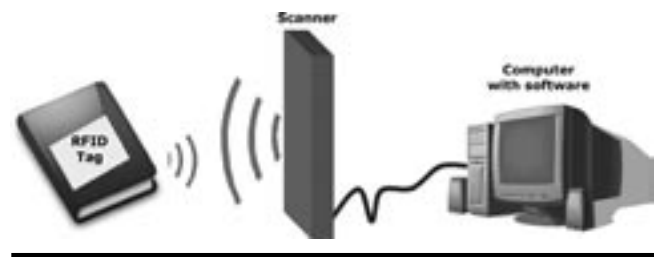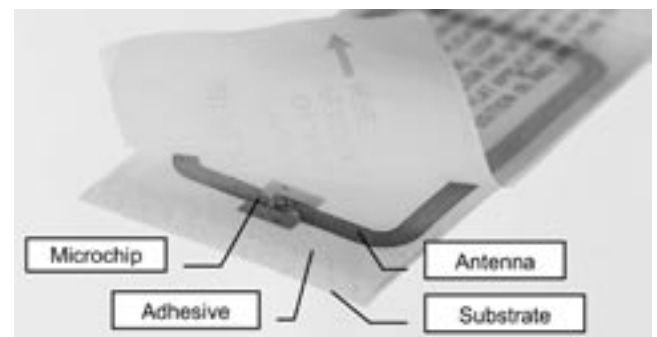

Figure 1. Components of an RFID system

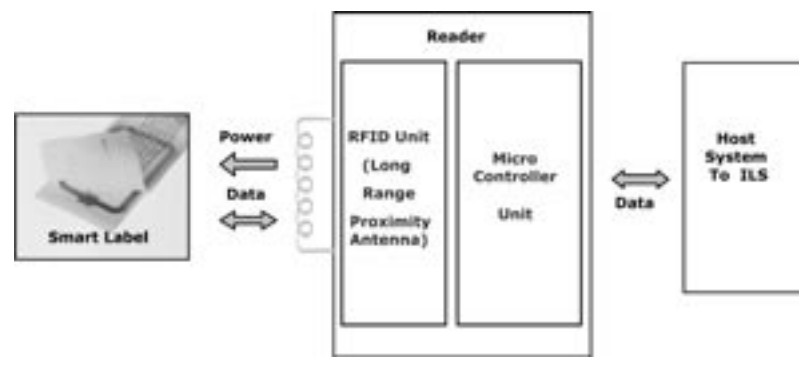**Figure 2.** Typical RFID tag

Figure 3. Information exchange for a typical RFID-based library (source: Libramation Library Systems)

read time is typically less than 100 milliseconds, and large numbers of tags can, in theory, be read at once, rather than item by item. Finally, unlike barcodes, RFID tags can be read even when they are not directly within the scanner's line of sight.[8]

■ RFID library system

There are various options that a library must consider before converting to RFID. Libramation Library Systems, an RFID library solutions vendor, participated in a separate study involving simulation of a complete RFID-based system at Cal Poly in May 2005. The system used 1024-bit (of which 896 bits are available for programming), 60 p/sec (gap pulse) anti-collision tags with Electronic Article Surveillance (EAS). The system operated at a frequency of 13.56 MHz and conformed to ISO 15693/18000 Standard. Various components associated with a library implementation were demonstrated.

Tag programming station

A programming (and verification) station is used to link the programmable code on the tag affixed to a volume to the existing bar code used for identifying it. This operation is very short and easy to perform. A rate of approximately 250 conversions per hour was achieved in trials at the Robert E. Kennedy Library. Figure 4 shows a typical programming station.

Self-checkout and check-in stations

These user-friendly stations are employed by patrons for checking out or returning items at the library. Easy-to-understand instructions in any language are possible to assist or prompt the patron through the process. Figure 5 depicts a typical self-serve station. These stations can be freestanding or counter-top, are adaptable to any existing form of patron membership card, and can be customized to the library's needs. Return stations can be placed at a convenient location outside the library for after-hours operations. Printed receipts confirming an interaction may also be issued. Based upon the operation, these stations are also capable of activating or deactivating the security bit in the tags. A checkout operation, for example, would require that the bit be deactivated in order for the patron to leave the premises without triggering an alarm.

Staff circulation desk

When used at library-staffed circulation desks, these ergonomically designed units have the capacity to reduce the number of movements by a staff member

Figure 4. Tag-programming station

Figure 5. Patron self-service station
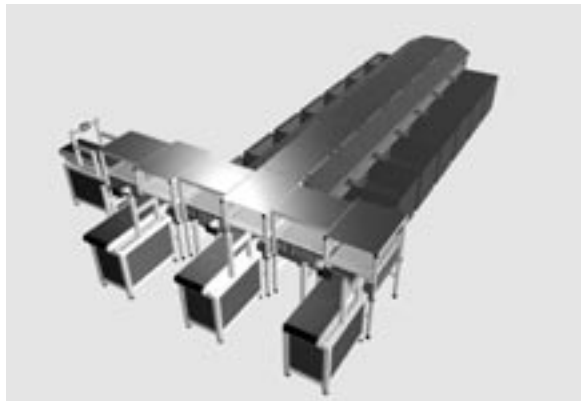
Figure 6. Hybrid circulation desk

Figure 7. Sorting station

for a typical task from approximately eight to ten (barcode/magnetic strip) to two to three (RFID) per item.[9] As with the self-serve stations, the units can be customized to the specific requirements of a library. Hybrid desks such as the one shown in figure 6 may be used to perform scanning of a barcode/magnetic strip and an RFID-based operation. Hybrid circulation desks permit patrons to scan their own library cards in order to initiate the check-out process. The staff member is able to view patron status on a flat screen monitor. She or he then slides each item by hand along the desk, where it passes over a built-in or top-mounted barcode scanner. An acoustic signal indicates that the scanner has successfully identified the item, circulation records are automatically updated, and the scanned materials are desensitized and passed to the client area of the desk for retrieval by the patron. To complete the process, the staff member presses a receipt key on a mini-keyboard to produce a printed receipt with due date.

Sorting stations

Most of the usual tedious and repetitive handling of material is eliminated with these stations since the sorting unit can separate library materials into individual material bins. This system can be modular and expandable and can greatly enhance the sorting process. The security bit on the tags is automatically activated upon sorting. Figure 7 shows one such unit marketed by Libramation Library Systems.

Security gates

EAS is an anti-theft system used by libraries. Pre-RFID systems utilized metallic security strips that needed to be desensitized—a separate action—during a normal checkout in order for patrons to exit the library without setting off an alarm. This security feature is incorporated by RFID technology in the tag itself and is much more conveniently activated or deactivated during the check-in or checkout operation. Security gates, which play a crucial role in preventing loss of library properties, typically set off an alarm when an unauthorized or improperly checked-out item is detected. A customized security gate by Libramation is shown in figure 8.

Portable readers

The promise of RFID is to dramatically reduce the time and effort of taking inventory. A handheld reader makes quick and easy work of shelf-management activities like weeding or finding missing and out-of-order books. In a vendor white paper supplied to the authors, VTLS, an RFID-solution vendor, claims to be able to inventory a collection of 250,000 books in less than four hours as compared to the thirty-five hours needed by the 3M portable reader.[10] It also claims that VTLS's portable readers can find one hundred books in a ten-thousand-book collection in approximately eight minutes, as compared to eighty-three minutes by 3M. The read speed claimed by VTLS is twenty books per second as compared with two for 3M. Figure 9 shows a Libramation Library Systems portable reader.

■ RFID library survey

This section summarizes the responses of twenty-nine libraries that participated in the survey conducted by the authors. Out of these twenty-nine, twenty-six public libraries, two academic libraries, and a corporate library were represented. The average number of hours of operation for all participating libraries was 104 hours per month, with an average seating capacity of 370. Eighty-nine percent of all survey participants reported less than

Figure 8. Security gate

Figure 9. Libramation's Lib-Chip handheld reader

or equal to 2 million user visits every year. The average collection size for the twenty-nine libraries was 1.34 million; the average circulation was 1.24 million per year. The participating libraries had an average interlibrary loan transaction of 760 per year. Because they address both security and inventory issues, interlibrary loan transactions play an important role when considering implementation of RFID technology in a consortial environment using a shared library management system. Library assets should be able to be processed by any member of the consortium in such an application.[11] The public libraries of Fresno County, California, serve as a good example of a consortia. They have thirty-four branches and started converting two of the branches to RFID last year.[12]

Migration to an RFID-based library system

Of the twenty-nine respondents, ten libraries had migrated to an RFID-based system and nineteen libraries had not. Out of the nineteen libraries that had not migrated, thir-
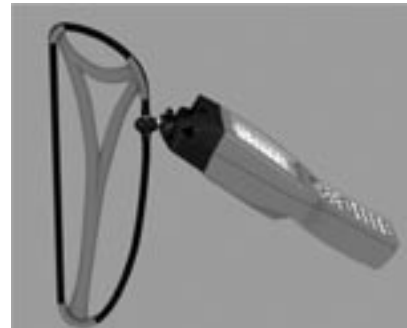
teen were in the process of migrating to RFID, four were considering migration, and two had no current plans for migration to an RFID-based library system.

According to the previously referenced Infopeople survey, of the approximately 51 percent of libraries that participated in their survey and were not considering implementing RFID, 58 percent expressed cost as the major issue and 9 percent listed privacy concerns.[13] Forty-eight percent of the participating libraries were considering RFID; these institutions suggested that the evaluation processes would be aided by: information from other libraries that had already implemented RFID systems (ranked the highest); a checklist of key questions to consider; RFID vendor product information; and additional information about privacy, security, and health concerns.

Conversion costs and time

Twelve quantitative responses were received for the Cal Poly survey. The conversion cost (actual or estimated) ranged from $113,000 to $1.2 million, with the average conversion cost being $502,917. These costs are difficult to gauge due to the number of variables, such as partial or complete conversion of collections, paid versus volunteer employee time, and the number of RFID system components such as number of self-checkout stations.

According to Vinod Chachra, CEO of VTLS, a full RFID implementation, including tags for books, readers, software, and self-checkout stations, runs around $1 per book. In comparison, the same implementation would have cost approximately $1.60 per book a year ago.[14] According to Boss, the cost of implementing an RFID system for a collection of forty thousand items would be $70,000; for a collection of one hundred thousand items, it would be $166,000.[15] Because his estimates were made in late 2003, they may be considerably high compared to the lower costs available now. Boss also provides estimates for individual RFID components in

his paper. Smart points out several main vendors that have led the market in providing libraries with equipment and training to converting their libraries to an RFID system.[16] She also provides ballpark figures of these vendors' charges to convert a mid-sized library of two hundred thousand items including two hundred thousand tags, one self-checkout, one self-return, and one entrance gate: 3M Library Systems is estimated to charge $175,000 to $275,000; Bibliotheca approximately $180,000; Libramation Library Systems approximately $125,000 to $160,000; Vernon Library Supplies $150,000; and Checkpoint between $100,000 and $130,000.

Conversion times (concluded or estimated) for sixteen libraries that have migrated or plan to migrate to RFID vary from one library to another. Three of those libraries took less than six months, eight libraries took or estimate that it will take twelve months, and the remaining three took eighteen months to switch to RFID. Two libraries did not have a definitive answer. The average conversion time was 11.18 months.

Boss estimates a typical training time of fifteen to twenty minutes for teaching a person to tag books.[17] A phased implementation is also recommended. According to Frank Mussche, president of Libramation, a good strategy for libraries not willing to convert their entire collections at once is to first tag their most circulated items instead of slowly phasing in the entire collection to an RFID-based management system.[18] Backroom stations and even the circulation desks can be used to convert any untagged items as they are returned to the library. This strategy allows a library to move from a barcode-only system to one that also has RFID capabilities without requiring a greater amount of resources than would otherwise be needed.

Staffing since RFID migration

Most of the responding libraries showed little to no changes in the number of employees. This may be attributed to recent migrations, expansion of facilities, or staff being reassigned to other duties. Three libraries, however, showed a significant difference in the number of employees prior to and after RFID adoption. All three attributed this to a facility expansion or a move to a new facility.

Due to the automation of circulation and inventorying of

a library's collection by an RFID-based system, the employees who typically perform such tasks have good reason to feel the threat of getting laid off. San Francisco and Berkeley Public Libraries in California are presently dealing with such issues.[19]

Circulation time since RFID implementation

There were ten responses for this question. Fifty percent of the participating libraries showed more than 10 percent increase in usage, as per the circulation stats, since RFID implementation. The responding libraries commented on a significant reduction in both check-in and checkout times and processes. Three of them provided quantitative responses that are presented in figure 10.

According to Checkpoint, an RFID vendor that claims that the system processes twenty items per second, libraries can realize as much as 75 percent reduction in handling time after installing their Intelligent Library System.[20] One key benefit of an RFID-based system as far as circulation is concerned is that it combines it with EAS. The security bit in a tag replaces the security strip needed with the barcode approach, and items can be moved in or out of the premises without performing two separate steps. The Mastics-Moriches Community Library in New York conducted a time and cost analysis to compare EAS and RFID systems for circulation and found that RFID gave a savings in labor time of up to 85 percent.[21] Figure 11 shows the results of the study.

Self-checkout rates tend to increase with easy-to-use circulation systems. Santa Clara Public Libraries, which in 2000 became the first system on the West Coast to adopt an RFID-based system, has achieved a self-checkout rate of 45 percent.[22] According to Margaret Hazel, Oregon Public Library's technology manager, the library has achieved a near 100 percent self-checkout rate.[23] Of note here is the fact that the Eugene Public Library has tagged all of its collection while the Santa Clara Public Libraries are still to tag such items as CDs and DVDs. Jackie Griffin,
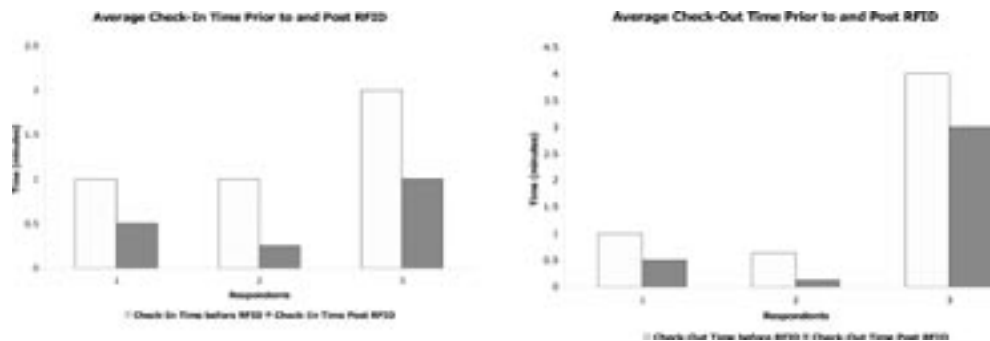

Figure 10. Circulation time since conversion

the library director at the Berkeley Public Library, estimates that self-checkouts at the library would jump from 15 to 90 percent after an RFID installation.[24] The Eugene Public Library reported "collision" problems on very thin materials and on videos as well as false readings from the RFID security gates. Collision problems mean that two or more tags are close enough to cancel the signals, making them undetectable by the RFID checkout and security systems.

RFID system features

An RFID system offers a variety of options. The various components needed to create a functional RFID library system depend on the unique requirements of individual libraries. Table 1 shows responses to the query regarding the various RFID system features, existing or sought, by the ten libraries that had already converted to RFID.

As can be seen, the patron self-checkout and conversion stations were deemed the most important RFID system feature, followed by security systems, staff service stations, inventory systems, and automatic book return systems, in that order. Of note is the fact that all of the responding libraries wanted to adopt the self-checkout units. This indicates that most of the libraries wanted to free up staff time from the repetitive task of circulating items. An automatic book return system, which can cost hundreds of thousands of dollars, was at the bottom of this list, most likely for financial reasons.

Figure 12 shows the number of self-checkout stations either existing or sought by the thirteen respondents to the question in the survey. They ranged from one to nine and averaged almost four per facility.

Security features

Two of the nine libraries that responded were using Checkpoint's RF system and seven were using 3M's Tattle Tape. The number of replacements of the pre-RFID security systems varied from twenty-five thousand to four hundred thousand.

Boss states that libraries with a properly tuned RFID-based security system reported a 50 to 75 percent reduc-

tion in false alarms at exit gates as compared to older RF or electromagnetic (EM) strip systems.[25] The RFID-based security process is automatic when an item is checked out at the circulation desk or at the self-checkout station, therefore eliminating the extra processing time of the staff or patron. Moreover, according to Bibliotheca, the accuracy rate of detecting a stolen item is very high, ranging from an average of 65 percent on conventional EM detection systems to almost 100 percent with an RFID system.[26] Bibliotheca also claims that staff cannot inadvertently damage audio-visual materials when desensitizing them. When a patron attempts to remove an item from the library without authorization, it is easily identified at the exit sensors by ID number, title, and author.

▮ Conclusion

RFID technology has several advantages over the current barcode systems being used at libraries worldwide. For the libraries that use it, RFID promises to save time and operate more efficiently and effectively than the barcode systems. Some of the compensations of RFID over a barcode system are that RFID tags can be used for security as well as for status control, thereby eliminating the need to attach security strips to library items; RFID systems make self-checkout faster and easier for library patrons; and RFID portable scanners can take inventory by just being passed slowly along the library shelves, without having to handle each item individually. RFID vendors, however, need to resolve some issues before libraries feel confident in adopting them. In the forefront are issues such as cost, lack of standardization amongst vendors, and privacy.

This survey investigated the state of RFID applications in libraries. Of the twenty-nine survey respondents, nineteen had not migrated to an RFID-based system. Of those nineteen, thirteen were in the process of migrating to RFID. This meant that nearly 80 percent of the libraries had or were seriously contemplating adopting an RFID-based library management system. For a library

Table 1. RFID system features existing or sought

	Patron self-checkout	Staff service stations	Inventory system	Automatic book return	Security system	Conversion stations
Yes	10	8	7	4	9	10
No	0	4	5	7	2	1
Had before	1	0	0	0	1	0
In progress	1	0	0	1	0	1
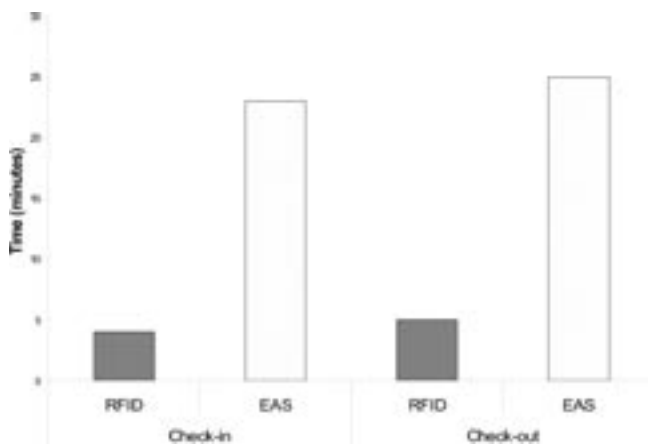
Figure 11. Time analysis of media circulation (source: www
.researchinformation.info/rimayjun04radiotagged.html)

Figure 12. Patron self-checkout stations existing or sought

collection size of 1.34 million items, the average conversion cost to migrate to an RFID system was $502,917. The average conversion time from a barcode-based system to an RFID-enabled system was 11.18 months. Based on ten responses, 50 percent of the participating libraries showed a greater than 10 percent increase in usage after RFID implementation. Average times for check-in and checkout were significantly reduced after implementation. The two most-installed or sought-after features were the patron self-checkout and the conversion stations. Seventy-eight percent of the libraries that responded used 3M's Tattle Tape system as a security feature, and the number of replacements of the pre-RFID security systems varied from twenty-five thousand to four hundred thousand.

Even though RFID tags may cost anywhere from four to five times as much as a barcode and magnetic strip combined, the increase in efficiency and functionality provided by the technology is persuasive enough for an increasing number of libraries to implement or consider this technology.[27] The number of RFID-enabled library systems is constantly increasing. International collaborations in such ventures are also on the rise. In a March 11, 2005, news release, the French RFID technology firm ASK was set to deliver some four million RFID labels to U.S. and European libraries. ASK has already supplied labels and readers to more than twenty French, Italian, and German libraries during the past four years.[28]

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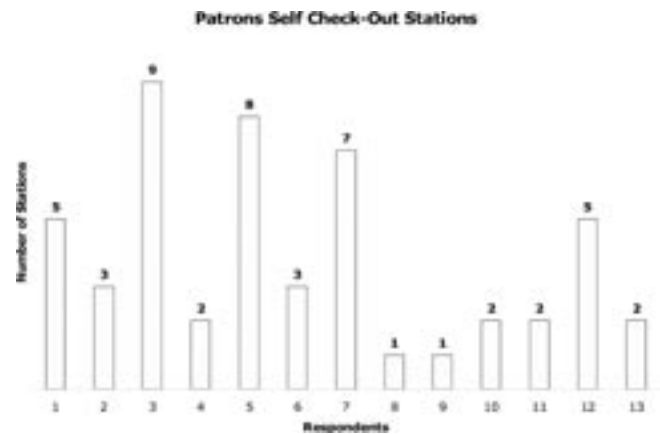Oct. 15, 2004. Accessed Nov. 16, 2004, http://mythic.lib.calpoly .edu:2067/universe/document?_m=aa31c69ea270d87b08.
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