



Implementation of Library Management System with RFID Technology

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Abstract: A library is a growing organism. As it grows in size the problems associated with the maintenance and security of the documents also grows. The researchers have always helped the librarian in solving their problems. To solve the problems of searching documents they have given cataloging guidelines. Bar-codes have served the librarians and libraries for a long time, and now it is slowly getting replaced by RFID. Radio Frequency Identification (RFID) is a new generation of Auto Identification and Data collection technology which helps to automate business processes and allows identification of large number of tagged objects like books, using radio waves. RFID based Library Management System (LMS) would allow fast transaction flow for the library and will prove immediate and long term benefits to library in traceability and security. The proposed system is based on Ultra High Frequency(UHF) RFID readers, supported with antennas at gate and transaction sections, and library cards containing RFID-transponders which are able to electronically store information that can be read / written even without the physical contact with the help of radio medium. This paper presents the technology implementation, features, the experiments conducted to set up RFID based LMS, possible problems of RFID in Library.

Keywords: Library, RFID, LMS, UHF, RFID-transponders

I. THE BACKGROUND TO RFID TECHNOLOGY

The ubiquitous barcode, such as diagrammatically portrayed in Figure 1, has been used since the late 1960's as a printed means of identifying product categories. The barcode system was effectively standardized with the widespread adoption in 1973, by users and equipment makers, of the Universal Product Code (UPC) 8 or 14 digit symbology. Since then there have developed different versions of this barcode technology (EAN, JAN) encompassing 8 to 14 digit systems.

Barcode technology continues to perform an essential role in inventory control and distribution, particularly in the consumer product market sector, but can be found in use from car manufacture to library stock control. Barcodes require close scanning with an optical reader, much like the laser scanning readers found at most supermarket checkouts.

A. Barcodes

- Are limited to the data printed on them and cannot be updated, other than by replacement or sticking a label over them (which may be labour intensive).
- Need to be substantially fat for reliable reading.
- Are typically (but not always) paper labels, or printed on paper based packaging, and therefore prone to damage.
- Typically provide inventory data to the level of product category.
- Are very unlikely to show through which distribution depots and transport means the product arrived at the point of sale.

RFID technology [1] has existed since the mid 1940s when it was used for military aircraft identification. Later high value goods inventory control applications were derived. In its early commercial manifestations each item to be tagged had a small electronic assembly (a transponder) fitted to it that would respond with a burst of radio frequency (RF) carrier modulated identification data when interrogated by a RF signal (on a different frequency) from either a hand-held scanner/reader, or one mounted, say, in a doorway. This burst of identifying data was intercepted by the scanner, decoded and used to both identify the tagged item and for it to be counted. The early RFID tagging means were battery powered (so called active devices). These were not only costly, but also relatively bulky. Since then RFID use, and potential, has greatly increased in large part due to the unit cost, size and power needs, of the essential 'tag' having decreased by many orders [2] [3] [8].



Figure.1 Barcode

Dependent upon the RFID technology used RFID memory does not have to be fixed but may be modified, extended/added to, or even erased. As will be seen RFID technology will overcome the limitations of barcodes. But as with barcodes, to gain wide international acceptance as the preferred means for inventory control systems there will have to be open standards for their. Further if RFID

technology is to become as ubiquitous as barcodes in the distribution chain, then the unit cost of the 'tag' will need to be substantially as cheap as the printed barcodes. Arguably, an RFID tag may never become as cheap as the printed barcode incorporated on the 'cereal box packaging', but because of RFID's advantages they may become the preferred inventory control means for consumer durables, and high value capital goods etc [6] [7].

B. Key components of an RFID System

In a basic RFID system, four fundamental components are required:

- A transponder (tag) that is programmed with information that uniquely identifies itself, thus the concept of "automatic identification"
- A transceiver (reader) to handle radio communication through the antennas and pass tag information to the outside world
- An antenna attached to the reader to communicate with transponders
- A reader interface layer, or middleware, which compresses thousands of tag signals into a single identification and also acts as a conduit between the RFID hardware elements to the client's application software systems, such as inventory, accounts receivable, shipping, logistics, and so on

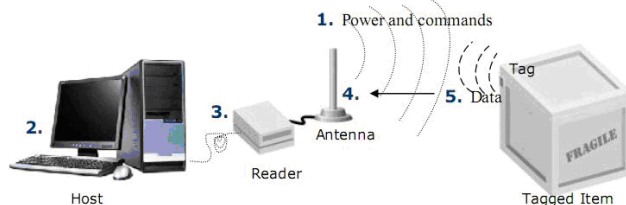


Figure.2. RFID system components

1. The tag is activated when it passes through a radio frequency field, which has been generated by an antenna attached to a reader.
2. The tag sends out a programmed response.
3. The antenna that generated the field originally and is attached to the reader detects that response.
4. The transceiver (or reader) sends the data to the middleware.
5. The middleware sends the information contained in the tags to whatever systems need that information.

II. HOW RFID WORKS

Each RFID tag has a non-powered radio antenna which can be communicated to by a powered antenna belonging to a tag reader on a scanner or security gate. Although it is not necessary that the two antennas "see" each other as is needed with a traditional bar code, it is necessary that they be relatively close to one another since the wattage used by the powered antenna is very low for health and safety reasons.

The RFID reader sends out electromagnetic waves and the tag antenna is enabled to receive these waves. "When the tag antenna enters the RF (radio frequency) field, the tag's microchip circuits are powered by signals from this RF field created by the reader. The chip then modulates the waves and the tag sends them back to the reader. The reader converts the signals received from the tag into digital data and sends it to a computer."

III. TECHNICAL SPECIFICATION

The project uses Workabout Pro UHF RFID handheld reader manufactured by Psion Teklogix, operating at 869.5 MHz. It has Windows Embedded CE 5.0 and full VGA, daylight readable touch screen display and well laid out backlit keyboard [9]. This device is used for searching Module.

The project also uses the Mercury4 RFID reader manufactured by ThingMagic supporting four antennas, operating at UHF ranges of 865-870MHz, 902-928MHz and 950-956MHz [10]. The reader supports the transfer of data to a remote computer over a network connection. The reader do support tag protocols of EPC Class 0, EPC Class 1, ISO 18000-6B, EPC Gen2 [9]. The antennas manufactured by Tyco electronics are used in this project.



Figure.3. RFID Handheld Reader



Figure.4. RFID Reader

RFID Tags used in the project are EPC global Generation2 (Gen2) UHF passive tags which have the 96 bits memory for hexadecimal data storage. It operates at Ultra High Frequency (850 MHz to 950 MHz) range.

A. Reasons for choosing UHF in Library Application

UHF technology was chosen for library application due to its long read range, speed of frequency and low cost. The read range of mercury 4 reader is up to 2 meters, which is sufficient to monitor the movement of books across the gates. The read range of psion-teklogix handheld reader is up to 30 cms which will be useful for locating a particular book in a rack. With the new EPC Global Gen 2 standard, over 1000 tags can be read per second in applications where they are insulated from RF noise. UHF also has the option to slow down the read process to 100 tags per second with high reliability in RF noisy applications. All of these benefits make the UHF technology the ideal choice for Library applications [11] [15].

IV. RFID TECHNOLOGY IN LIBRARIES

RFID (Radio Frequency IDentification) is the latest technology to be used in library theft detection systems. Unlike EM (Electro-Mechanical) and RF (Radio Frequency) systems, which have been used in libraries for decades,

RFID-based systems move beyond security to become tracking systems that combine security with more efficient tracking of materials throughout the library, including easier and faster charge and discharge, inventorying, and materials handling [4] [5].

RFID is a combination of radio-frequency-based technology and microchip technology. The information contained on microchips in the tags affixed to library materials is read using radio frequency technology regardless of item orientation or alignment (i.e., the technology does not require line-of-sight or a fixed plane to read tags as do traditional theft detection systems) and distance from the item is not a critical factor except in the case of extra-wide exit gates. The corridors at the building exit(s) can be as wide as four feet because the tags can be read at a distance of up to two feet by each of two parallel exit sensors. The targets used in RFID systems can replace both EM or RF theft detection targets and barcodes.

V. FEATURES OF RFID LIBRARY MANAGEMENT



A. Tagging or Patron Card Process System

1) Components:

1. Card Printer (Double Side printing)
2. Digital Webcam & Tripod
3. Mid Range RFID Reader/Writer
4. Capture, Edit & Printing Software
5. Price not include PC & Monitor

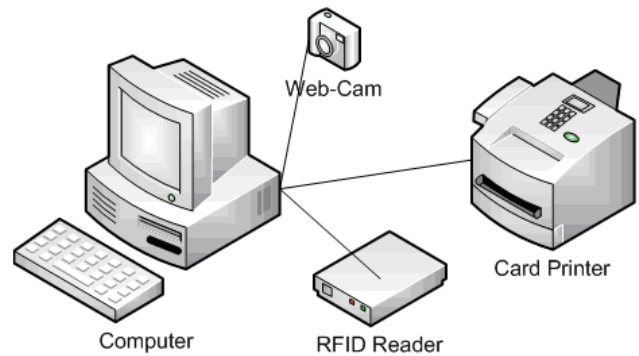


Figure.5. Patron Card Process System

2) Key Benefits:

- Double Side Card Printing will set librarian print patron card without changing side of card.
- Library can make patron card in quick way and without patron to bring their own photo.
- It is best way to serve patron.
- Connect to Integrated Library System Directly (this option depend on ILS/LMS system) [14].

B. Check out / in Station (Counter Station)

The Counter Station is a staff assisted station on services such as loan, return, tagging, sorting and etc. It is loaded with arming/disarming module, tagging module and sorting module. Arming/Disarming module allows EAS (Electronic Article Surveillance) bit inside the tag of the library material to be set/reset so as to trigger/not trigger the alarm of the EAS gate. Checking of EAS status of library material is easy. The staff puts the item on the reader and click on the view to display the information stored inside the tag and status of EAS. There are also feature of Auto Arming and Auto Disarm. Auto Arm/Disarm will automatic arm/disarm library material that is within the Reader range [14].



Figure.6. Counter Station

Together with circulation module from Library Management System Software, this station is used for the following services:

- Editing and updating of patron's record
- Add and deleting of patron's record
- Generate loan history for a particular patrons
- Managing of fines incurred by the patron
- Arm/Disarm of EAS bit inside the library material
- Program of new library material
- Sort item in accordance to their branch and category number
- The features of this station depend on the module loaded by the Library Management Software.

1) Key Benefits:

- Provide Value Added Customer Service instead of manual daily routine
- Perform media check-in/-out for those patrons who choose not to use the self service system
- Help patron that need assistance from the staff

C. Self Check out / in Station

The Patron Self Check-out station is basically a computer with a touch screen and a built-in RFID reader, plus special software for personal identification, book and other media handling and circulation. After identifying the patron with a library ID card, a barcode card, or his personal ID number (PIN), the patron is asked to choose the next action (check-out of one or several books). After choosing check-out, the patron puts the book(s) in front of the screen on the RFID reader and the display will show the book title and its ID number (other optional information can be shown if desired) which have been checked out [12] [13].



Figure.7. Self Check out / in Station

The patron then confirms that he has finished the check-out process and a receipt is printed, showing which books have been borrowed and the return date. The RFID tag in the book is set on quiet as a result no alarm will go off at the EAS gates.

It is also possible to use the station for Check-In (return) of books. In this case the patron identifies herself, chooses return and then puts one book or a stack of books onto the reader. She will receive a receipt. If the books were to be taken through the gate now, an alarm would sound.

One important point for library productivity is that the whole process is significantly less time consuming than with barcode and magnetic strip system; therefore long lines are avoided and fewer stations are needed for the same process.

1) Key Benefits:

1. To Librarian:
 - Speeds up book check-in / check-out
 - Frees staff to better service patrons
 - Better space planning
 - Increases membership rate
2. To Patrons:
 - Easy to use: books can be read in any orientation

- Reduces queuing time
- Provides patron privacy
- Encourages patrons to come back

D. Anti-theft Detection

The RFID EAS Gates is the anti-theft part of the Library RFID Management System using the same RFID tags embedded in the library items. Each lane is able to track items of about 1 meter and would trigger the alarm system when an un-borrowed item passed through them. The alarm will sound and lights on the gate will flash as patron passes through with the un-borrowed library material.

The EAS Anti-Theft Gates is used to detect RFID tag that is equipped with EAS (Electronic Article Surveillance). It can detect the RFID tags within 1 meter range without interference of magnetic items, upon detecting of Armed RFID tags, the alarm will sound on the gate. It has option to trigger a Camera to record patrons who trigger the alarm to the Surveillance Station.



Figure.8. Anti-theft Detection System

Theft detection is an integral feature of the chip within the tag. It is a stand-alone technology, which operates independently of the library database.

1) Features:

- Detect EAS Armed RFID tags
- Multi-item detection
- Able to integrate camera with the gate (Option)
- Gate to integrate with Surveillance Station (Option)

2) Key Benefits:

- Single technology is required for both inventory and theft management of the library.
- Library staff is alerted immediately when un-borrowed items pass through the theft detection gates.
- Would-be thieves are deterred by the physical presence of the gates.
- Number of patrons passing through the gates is captured by a counter on the gates Alarm volume can be easily controlled.

E. Book-Drop (Return Station)

The Book Drops can be located anywhere, within or outside the library. Possible remote locations outside the library include MRT/train stations, shopping centers, schools; etc. This offers unprecedented flexibility and convenience of returning library items at anytime of the day, even when the library is closed.

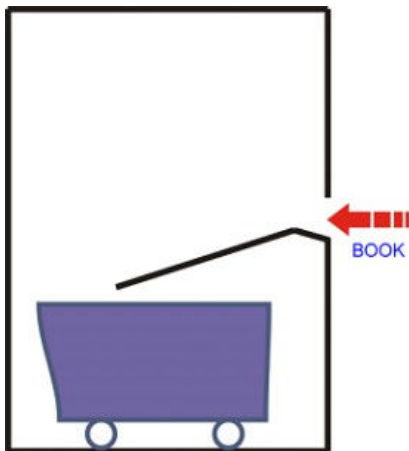


Figure.9. Book Drop

Patron inserts the library item into the slot. The reader captures the electronic signature and sends to backend system for loan cancellation. Patron is acknowledged by beeping sound and flashlight. Patron's record is updated immediately. This is possible due to the seamless link between Library RFID Management System and the host computer system. As such, users who have reached their loan quota can start borrowing items once they have returned them through the Book Drop.

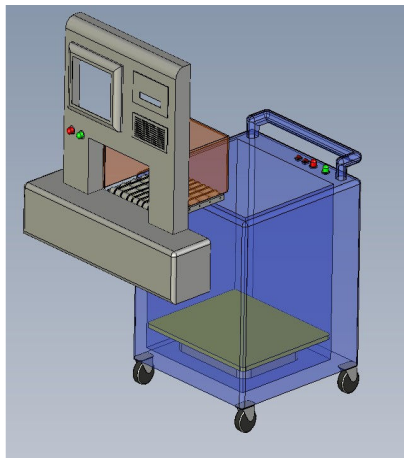


Figure.10. Return Station

1) Key Benefits:

- The ability to return books during off hours.
- Loans for the returned items will be instantaneously cancelled so that patron may immediately borrow again.
- Librarians are able to allocate more time to customer service, as they are free from the labor-intensive loan cancellation activity associated with barcode system.
- Display the return status and printing receipt.
- The design of the Book Drops is such that items cannot be retrieved back once deposited.

F. Shelf Management System

The Shelf Management Solution makes locating and identifying items on the shelves an easy task for librarians. It comprises basically of a portable scanner and a base station [16].

The solution is designed to cover three main requirements:

- Search for individual books requested
- Inventory check of the whole library stock
- Search for books which are miss-helved

All these functions are performed by sweeping the portable scanner across the spines of the books on the shelves to gather their identities. In an inventory check situation, the identities collected are compared with the database and a discrepancy report could be generated.

In situations when search function is required, whether for a particular item or an item category, the information is first entered into the portable scanner from the base station, and when a foreign item is found on the shelves, a built-in beeper sound to alert the librarians.

1) Key Benefits:

(a) Changes inventory process:

- No more book handling: just pass the reader across shelved books to perform an instant inventory.
- Accuracy: book identification numbers are registered in the Shelf-Management Reader. The data is then downloaded to the central database.
- The fastest inventory you have ever made: 20 books per second.
- Notification: books to be pulled are up-loaded to the reader for quick identification.

(b) User friendly:

- Light weight
- Wand allows easy reading of high and low shelves

(c) Saves time and resources:

- Implementers indicate a 75% reduction in human resources required for shelf management activities.



Figure.11.RFID Scanner

VI. RFID INTEGRATION MODULES

In order to provide RFID integration with LMS, three modules namely - Transaction Module, Monitoring Module and Searching Module were developed. Their functionalities are described below.

A. Transaction Module

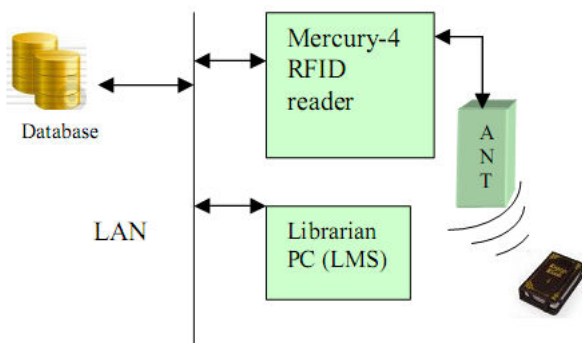


Figure.12. Interaction of Transaction Module

The interaction of transaction module is given in (fig. 12). The RFID interface is provided in the transaction forms like issue, reissue, return and fine status forms. The Manual intervention is minimized as the automatic identification of books and library members will be achieved because of RFID. The books and employee ID cards should be placed near the antenna. The tags will be scanned by the reader and the book id and the employee id will be transmitted to the s/w module running in the librarian's PC and which in turn will store the transaction information in database with timestamp.

B. Monitoring Module

The Monitoring System (fig.13) will be installed at the gates of the library to monitor the incoming/outgoing bags continuously. The System will communicate with the Mercury 4 RFID reader through socket using RQL. The reader scans the RFID tags attached with the books and library member cards and will send the tag IDs to the monitoring system which in turn will save that information in database with timestamp. The system differentiates the book IDs and library member IDs by checking the format of the ID value. There is an instant display system which will continuously display the movement of incoming/outgoing books/library-members. The System alarms the librarians whenever there is a movement at the gates without prior issue.

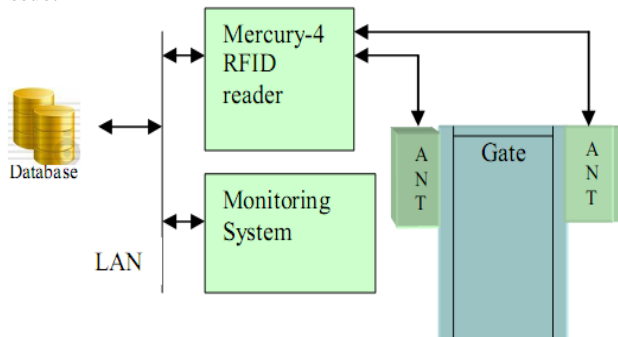


Figure.13. Interaction of Monitoring Module

C. Searching Module

The interaction of searching module is given in fig.14. Once a user has located a resource within the catalog, they must then utilize navigational guidance to retrieve the resource physically; a process that may be assisted through RFID tagging. Using RFID tags to track library books could increase security and ease laborious stock takes. The RFID tag attached with the books contains the book number. The books will be searched with the help of the RFID handheld

reader using any of the parameters like book no, book name, author name and publisher name.

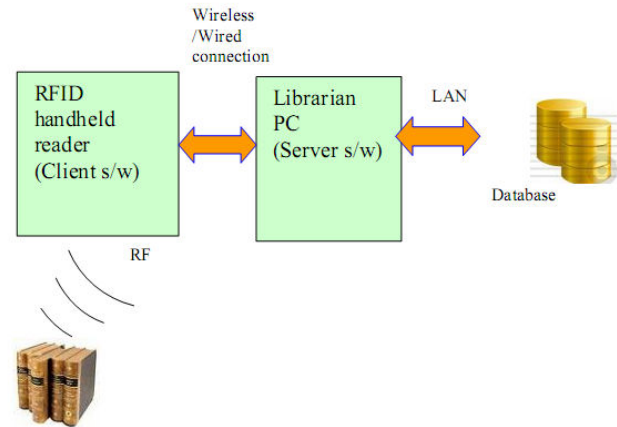


Figure.14. Interaction of Searching Module

If the book no. is directly given as a searching parameter, the client s/w will start locating the book immediately. The beep sound will be given as soon as the particular book is identified. If other parameters like book name, author name and publisher names are given as a searching condition, then the client s/w communicates with the server program to get the required book id from database by matching those parameters. If more than one book, are satisfying the search condition, then the librarian will be asked to select a particular book among those books.

The main benefit is that books can be checked quickly using a handheld reader, reducing the stocktaking time from weeks to half a day.

VII. EXPERIMENTS ON POSITION OF TAGS IN BOOKS

The main motive of using RFID technology is to decrease the time consumption of every task and to get 100% readability of tags. To achieve this, best tag position has to be identified to make sure that none of the tags gets compromised with reader in terms of getting hidden by the human body while carrying the books. Hence, different tag positions have been taken into consideration and have been checked for its readability. Though there are several options to compromise the reader by hiding the tag deliberately using aluminium material or any kind of metals etc., our motive is to maximize the readability of tags in normal conditions. Different possible tag positions in a book are illustrated in figure15.

A. Test results of Monitoring Module

Sample size of 60 books of different sizes was taken and checked with all the tag positions in the environment of single antenna kept at the height of 1.5 meters from the ground. Simulation test was conducted to find out the percentage of books detected by RFID reader when people were made to move by holding the books in different ways across the gates.

The result is as shown in the table I.

TABLE.I

TAG POSITION - MONITORING MODULE

Tag Position	Total Books	Read%	Avg. Distance (Cms)
1	60	63	86
2	60	77	76
3	60	85	91
4	60	65	71

5	60	80	65
6	60	77	65
7	60	87	87
8	60	55	70
9	60	40	60

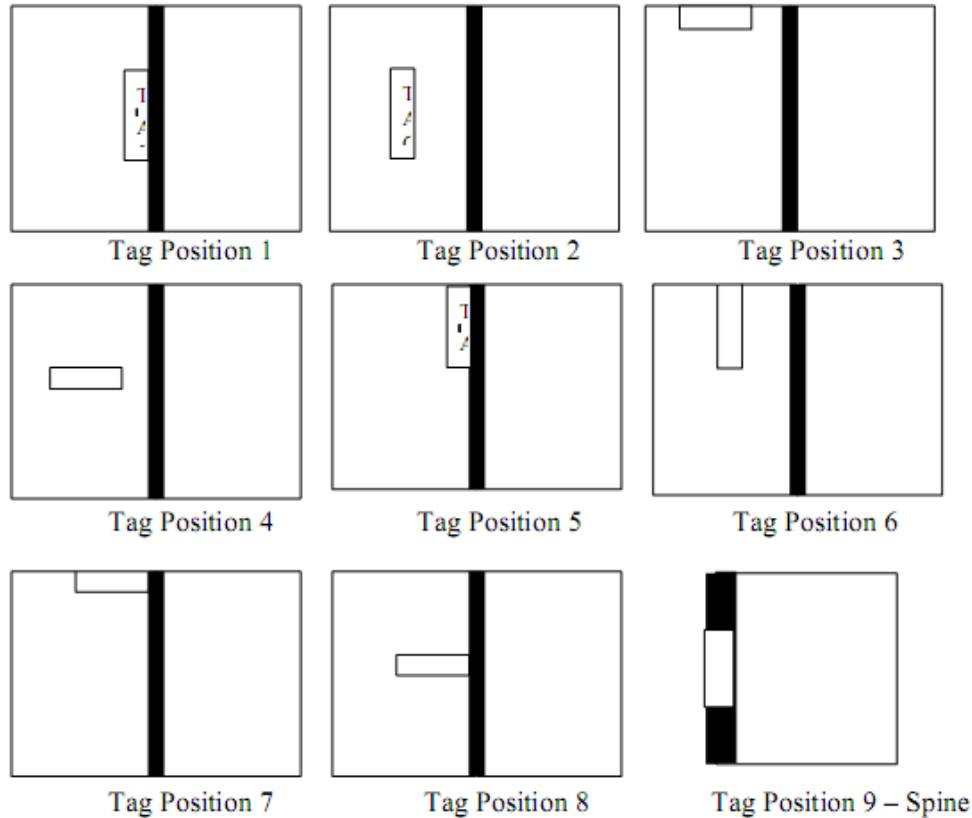


Figure.15. Different Tag Positions

When same test was conducted with 2 antennas at the two sides of the gate, 100% detection was found for the tag position -7, and 98% detection was found for the tag position-3, both with the average maximum read distance of 1.5 meters. The performance of the software has been tuned to read the tags within 2 seconds which is the time normally people take to cross the 1.5 meters distance in library.

B. Test results of Searching Module

The books of different sizes kept in 8 racks have been checked with the different tag positions to find out the percentage of tags detected by the handheld reader. The result is as shown in the table-II.

The results indicated that tag position 1, 2, 5 and 9 gave maximum percentage of 92%, 90%, 89% and 96% respectively. But these positions didn't hold good for the monitoring module as these positions are prone to be hidden

by human hand or body while carrying the books in the gate region of library. Based on composite results from Table I and Table II, Tag position 7 is identified for the final deployment of the project. RFID tags will be pasted in all books in this position.

TABLE.II

TAG POSITION - SEARCHING MODULE

Tag Position	Total Books	Read%
1	100	92
2	100	90
3	100	76
4	100	56
5	100	89
6	100	86
7	100	88
8	100	67
9	100	96

VIII. POSSIBLE PROBLEMS

RFID technology will continuously communicate with the library database, the real danger of merging this technology is in letting secure integrated library system (ILS) database be contacted/updated/opened several times and thereby make them prone to hackers [3].

Some of the technological problems that may occur with RFID applications in libraries are:

- RFID tags are not hidden since these tags are typically affixed to the inside back cover and are exposed to vandalism.
- Some interference from metallic material in book covers, CDs and DVDs does occur and tag reading may not be correct.
- RFID tags are easy to shield from readers by ordinary aluminum foils and may not serve the purpose of being anti-theft tools.
- RFID reading accuracy declines if many items are read simultaneously
- RFID reader range depends on its power and antenna size.

In addition to these technical problems, there may be other difficulties in implementing RFID systems in libraries. Some of these are:

- Privacy issues.
- Forward (future) compatibility and inter-library operations due to differences in tags or software.
- Limitations in reorganization of library spaces.
- Metal shelves may hinder operations of readers and sensors.
- Operational difficulties such as installation of return chutes, provision of power supply near the self check-in/check-out desks or chutes.
- Budget restrictions for technology upgradation as RFID tags are more expensive than barcodes and security strips.

IX. CONCLUSION

Patron satisfaction has become a crucial issue for librarians. Though the unique advantages and flexibility of RFID is the good news, the technology is still not yet widely understood or installed in the library environment. RFID, its application, standardization, and innovation are constantly changing. Its adoption is still relatively new and hence there are many features of the technology that are not well understood by the general populace. Developments in RFID technology continue to yield larger memory capacities, wider reading ranges, and faster processing. "RFID is

increasing in popularity among libraries, as the early adopters of this technology have shown that, it makes good economic sense, both for large and small libraries."

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