

RFID Technology at Central Library, IIT Madras

An Overview *By*

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Abstract: - This paper gives brief idea about the emerging Radio Frequency Identification (RFID) technology, its importance in the library management system and its working. It also describes about the basic components required for smooth working of the exercise. It outlines various advantages and disadvantages of RFID technology in libraries. Besides, it gives focus on the implementation of RFID technology at central library, IITM. This will provide new insight for other libraries to implement RFID system.

Keywords: - RFID, Components of RFID, Advantages & Disadvantages, Implementation of RFID

1. INTRODUCTION

The **Indian Institutes of Technology (IITs)** is an autonomous public institutes of higher education, located in India. They are governed by the *Institutes of Technology Act, 1961* which has declared them as "institutions of national importance", and lays down their powers, duties, framework for governance etc. The Institutes of Technology Act, 1961 lists sixteen institutes located at Kharagpur, Bombay, Delhi, Kanpur, Madras, Guwahati, Roorkee, Hyderabad, Patna, Bhubaneswar, Ropar, Jodhpur, Gandhinagar, Indore, Mandi and Varanasi. Each IIT is an autonomous institution, linked to the others through a common IIT Council, which oversees their administration. Among these above sixteen institutes the **Indian Institute of Technology, Madras** was recognised as the third Indian Institute of Technology that was established by the Government of India through an Act of Parliament, to provide education and research facilities in engineering and technology. The **Indian Institute of Technology Madras (IIT Madras)** or IIT-M is a premier autonomous public engineering and research institution located in Chennai (formerly Madras), Tamil Nadu in front of Anna University. It is recognised as an Institute of National Importance by the Government of India.

The Central Library is well equipped with modern facilities and resources in the form of CD-ROMs, On-line databases, audio video cassettes, books, e-journals, patents, e-standards, theses, reports, mono-graphs etc. The Central Library is to provide information services and access to bibliographic and full text digital and printed resources to support the scholarly and informational needs of the Institute Community. The Central Library has also implemented Integrated RFID Technology, Smart Card, ISO-9001:2000 Standards, Contactless Smart Card Enabled Access Control System, Virtual Reference Desk, Electronic Book Drop System, Auto Check in and Check out Systems, Z39.50, Web Portal, Research Carrels, Media Resource Centre with 200 seating capacity, Students Discussion Hall, Automatic Bindery and world-class facilities, services, multi format resources. The various services includes OPAC, Self Check in/Check out, Self-Renewal of Books, Electronic Book Drop, Book Bank, Access to Abstracts of Publications through I-Portal, Translation, Book Reservation, Video Viewing, Inter- Library loan, Document Delivery, Reading, Access to E-Resources, Bibliographical Compilation, Patents Information, Standards Information Service, Technical Consultancy, Photocopying, JCCC.

2. INTRODUCTION TO RFID TECHNOLOGY

RFID (Radio Frequency Identification) invented in 1969, patented in 1973, first used in harsh industrial environment in 1980s', and standards presented in 2001, is the latest addition of technology to be used in the libraries for a combination of automation and security activities in the well maintenance of documents either inside the library or goes out-of library. RFID uses wireless radio communications to uniquely identify objects or people, and is one of the fastest growing automatic data collection (ADC) technologies, which is comprising one or more reader/interrogators and RF transponders in which data transfer is achieved by means of suitably modulated inductive or radiating electro-magnetic carriers.

RFID is a combination of radio-frequency and microchip. RFI chips are of particular interest, because they have become smaller and smarter to the point where they can be added every kind of document and can be read and updated from a distance .

RFID is an innovative automated library system for automatic identification and tracking of library material. It is combination of radio-frequency-based technology and microchip technology and can be used to identify, track, sort or detect library holdings. This is an

effective way of managing collections of the library and providing enhanced services to the users having benefits like: to control increasing theft, to find misplaced reading material, inventory accuracy, stock verification procedures, security control, etc. It is an automatic data capture technology that uses tiny microchips and miniature antennas affixed to products. RFID plays a vital role in redefining the library processes to make everyone's job easier right from the users to library staff. It provides a platform to automate most of the processes performed by the library staff like check in-check out, sorting, stock management, etc. An RFID system consists of three components: a tag (or multiple tags), a reader or interrogator and the necessary supporting infrastructure (both hardware and software). An RFID reader, or interrogator, is a device to communicate with the RFID tag. It also broadcasts a radio signal, which is received by the tag. The tag then transmits its information back to the reader. Readers can either be portable handheld terminals or fixed devices that can be positioned at strategic places.

The main aim for today's libraries in adopting RFID is to improve library operations by increasing the efficiency of library transactions, reducing workplace injuries, and improving services for library users. Library manpower can be utilized to provide more value added services. RFID enables savings in costs-materials and manpower and ensures more efficient operations. RFID helps the librarian in providing the users with optimum utilization of available resources.

3. RFID CONCEPTS

RFID is an acronym for radio frequency identification, which is a wireless communication technology that is used to uniquely identify tagged objects. (Daniel et al., 2007)

According to Wikipedia, Radio-Frequency Identification (RFID) is an automatic identification method, relying on storing and remotely retrieving data using devices called RFID. (www.wikipedia.com)

Technovelgy.com has defined RFID as a small electronic device that consist of a small chip and an antenna. The chip typically is capable of carrying 2,000 bytes of data or less. (www.technovelgy.com).

According to Automatic Identification and Data Capture (AIDC), "Radio Frequency identification is a technology that uses radio waves to transfer data between a reader and an

electronic tag which is attached to a particular object. Typical uses are for object identification and tracking".

According to Harrods's Librarians' Glossary and Reference Book, "Radio Frequency Identification, an alternative to the Bar Code that uses tiny microchips in tags to hold and transmit detailed data about the item tagged. RFID has advantages over bar codes such as the ability to hold more data, the ability to change the stored data as processing occurs, it does not require line-of-sight to transfer data and is very effective in harsh environments where bar code labels may not work". RFID thus is a generic term for technologies that use radio waves to automatically identify people or objects.

Radio frequency identification is a system that facilitates the tracking of objects, primarily for inventory tracking, via a three part technology comprised of a reader, a transceiver with decoder and a transponder (Radio Frequency-Tag). RFID is a wireless system that works in conjunction with an organization's information technology infrastructure to improve business processes such as inventory management and efficiency in supply chain management (Nisha et al., 2006).

Hence, RFID is a means of identifying a person or object using a radio frequency transmission. These wireless automatic identification data capture system allows for noncontact reading or writing of data and are highly effective in environments where barcode labels cannot survive. "RFID is a combination of radio frequency based and microchip technology. An RFID system consists of an antenna and a transceiver, which read the radio frequency and transfer the information to a processing device, and a transponder, or tag, which is an integrated circuit containing the Radio Frequency circuitry and information to be transmitted.

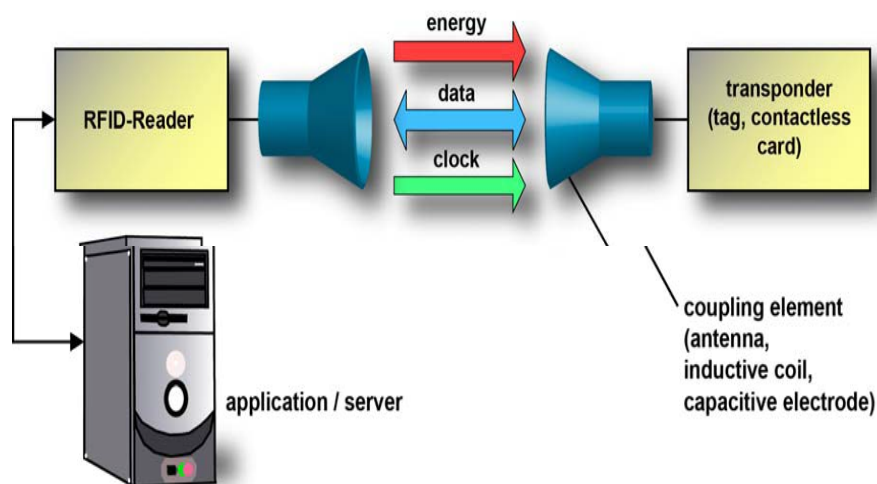
4. COMPONENTS OF RFID SYSTEM

RFID system has mainly four components:

- **RFID Tag:** An RFID tag is a tiny radio device that is also referred to as transponder, smart tag, smart label, or radio barcode. There are two main components present in the RFID tag. Firstly, a small silicon chip or integrated circuit which contains a unique identification number (ID). Secondly, an antenna that sends and receives radio

waves. The antenna consists of a flat, metallic conductive coil and the chip which is less than half a millimetre. Tags are of three basic types: Passive, Active & Semi-passive tags. They can also be read-only or provide read-write capability.

- **Readers and Antenna:** The second component in a basic RFID system is the interrogator or reader. Technically, reader units are transceivers (i.e., a combination of transmitter and receiver) and their usual role is to query a tag and receive data from it. RFID reader converts radio waves from RFID tags into a form that can be passed to middleware software. An RFID tag reader use antennas to communicate with the RFID chip. It can read information stored in the RFID tag and also update RFID tag with the new information. Hence, RFID reader accomplishes two tasks: it receives commands from the application software and communicates with tags.
- **Middleware:** Both middleware and software applications are required in an RFID environment. Middleware manages the flow of information between the readers and the backend. In addition to extracting data from the RFID tags and managing data flow to the backend, middleware perform functions such as basic filtering and reader integration and control. RFID middleware assist with retrieving data from readers, filtering data feeds to application software, generating inventory movement notifications, monitoring tag and reader network performance, capturing history and analyzing tag-read events for application tuning and optimization.
- **Server:** A server may be configured with an RFID system. It is a communication gateway among the various components. It receives the information from one or more readers and checks the information against its own database or exchanges information with the circulation database of the library integrated management system. The server typically includes a transaction database so that the reports can be produced.



5. LITERATURE REVIEW

A **literature review** is a text of a scholarly paper, which includes the current knowledge including substantive findings, as well as theoretical and methodological contributions to a particular topic. Radio Frequency Identification (RFID) is an upcoming technology which has recently attracted the interest of the research community because of the extraordinary benefits it offers over the other existing identification and data capturing technologies.

A significant number of RFID studies were devoted to the technical improvement of RFID technologies. Mechanisms to reduce collision among RFID readers in dense and dynamic RFID environments suggested by Eom, et al (2009), Hsu, et al. (2009) and Chen, et al. (2009). Lin and Ho (2009) suggested that there is a positive relationship between the willingness to adopt RFID technology and supply chain performance for logistics service providers. Lee et al. (2009) developed a framework for automating the processes in a manufacturing environment using RFID. Venable (2006), Pries-Heje, Baskerville and Venable (2008) pointed out that that design science research has two primary forms: artificial and naturalistic evaluation. Artificial evaluation evaluates a solution technology in a contrived and nonrealistic way, while naturalistic evaluation explores the performance of a solution technology its real environment. It was also highlighted that naturalistic evaluation is critical as it tests the —real proof the pudding. This concept is in harmony with this paper as it describes a set of experimental procedures to evaluate the performance of a RFID reader in

its operating environment. Curran and Porter (2007) have proposed and outlined a library prototype that utilizes Radio Frequency Identification (RFID) to enhance and speed up the current customer book search and identification processes. The hardware used in the design and implementation of the prototypes are a laptop to host the server, a router to create the wireless network, a PDA to host the applications, RFID tags and an RFID reader to carry out the RFID communication. The user can search for a book on the shelf by entering the book information in any of the search criteria text boxes and pressing the Search button. The system has to search the database to return the appropriate book. The functionality and benefits offered by the RFID systems match the needs and areas of improvement for libraries. The development and evaluation of the library application has demonstrated that RFID can be successfully integrated into library systems. Dai Yu (2011) in his case study on the Turku City Library on implementing RFID Technology in Library Systems focused on the management aspect of a library particularly the self service support system for patrons by introducing RFID system. Based on a comparative study between the barcode and RFID applications, it is stressed on the many benefits of RFID. However, challenges are many and are pointed out as those of tracking and hot listing. Moreover, depending on the strength of the RFID reader it is possible to either greatly hinder or completely block the tag signal by wrapping an item, embedded with several layers of aluminum or tin foil. This combined with a weak gate sensor, makes risk of item getting stolen quite high. Syed Md Shahid (2005) considers RFID applications in circulation, tracking, inventorying and security of library materials as well as discusses on the various components of the RFID system in details followed by its installation features. At the same time, he states that it is important to educate library staff and library users about RFID technology before implementing a program.

Serge Vaudenay (2001) deals in preparing a model based purely on the security and privacy of the RFID tags and assumes a powerful adversary who can control all communications mandating the use of some public key cryptography techniques while discussing on tag corruptions and availability of side channels. David Alexander Molnar studies the security and privacy in deployments of RFID technology and proposes novel mechanism for improving RFID privacy for library books and electronic passport and deals with private authentication. He also discuss broadly on the different eavesdropping ranges, repetitive

stress injuries, streamline mechanism and RFID as an enabler for automatic sorting on book check-in.

The most appropriate method of adopting RFID (Cheung, Chu & Du Timon, 2009; Lee, Cheung, Kwok, Chan, Chan & Leung, 2009; Lee & Chan, 2009). For example, Lee et al. (2009) developed a framework for automating the processes in a manufacturing environment using RFID while Lee and Chan (2009) suggested the use of RFID to support reverse logistic system by counting the quantities of collected items in collection points and sending the signal to the central return centre.

Kapoor et al. (2009) identified and discussed critical issues in the implementation of RFID in supply chain management such as ownership transfer, privacy/security, computing bottleneck, and read error. They also discussed cost-benefit issues such as opportunity cost, risk of obsolescence, information sharing, and interoperability standards.

6. ADVANTAGES AND DISADVANTAGES OF RFID SYSTEM

Advantages:-

The main advantages of RFID system are as follows:-

- **Rapid charging/discharging:** The use of RFID reduces the amount of time required to perform circulation operations. The most significant time savings are attributable to the facts that information can be read from RFID tags much faster than from barcodes and that several items in a stack can be read at the same time. While initially unreliable, the anti-collision algorithm that allows an entire stack to be charged or discharged now appears to be working well.
- **Simplified patron self-charging/discharging:** For patrons using self-charging, there is a marked improvement because they do not have to carefully place materials within a designated template and they can charge several items at the same time. Patron self-charging shifts that work from staff to patrons. Staff is relieved further when readers are installed in book drops.

- **High reliability:** The readers are highly reliable. Some RFID systems have an interface between the exit sensors and the circulation system to identify the items moving out of the library. Were a patron to run out of the library and not be intercepted, the library would at least know what had been stolen. If the patron card also has an RFID tag, the library will also be able to determine who removed the items without properly charging them. This is done by designating a bit as the "theft" bit and turning it off at time of charge and on at time of discharge.
- **High-speed inventorying:** unique advantage of RFID systems is their ability to scan books on the shelves without tipping them out or removing them. A hand-held inventory reader can be moved rapidly across a shelf of books to read all of the unique identification information. Using wireless technology, it is possible not only to update the inventory, but also to identify items which are out of proper order.
- **Automated materials handling:** Another application of RFID technology is automated materials handling. This includes conveyor and sorting systems that can move library materials and sort them by category into separate bins or onto separate carts. This significantly reduces the amount of staff time required to ready materials for reshelving. Given the high cost of the equipment, this application has not been widely used.
- **Long tag life:** Finally, RFID tags last longer than barcodes because nothing comes into contact with them. Most RFID vendors claim a minimum of 100,000 transactions before a tag may need to be replaced.
- **Fast Track Circulation Operation:** The use of RFID reduces the amount of time required to perform circulation operations. The most significant time savings are attributable to the facts that information can be read from RFID tags much faster than from barcodes and that several items in a stack can be read at the same time. While initially unreliable, the anti-collision algorithm that allows an entire stack to be charged or discharged now appears to be working well.

Disadvantages:-

The main disadvantages of RFID system are as follows:-

- **High cost:** The major disadvantage of RFID technology is its cost.
- **Vulnerability to compromise:** It is possible to compromise an RFID system by wrapping the household foil to block the radio signal. It is also possible to compromise an RFID system by placing two items against one another so that one tag overlays another. That may cancel out the signals. This requires knowledge of the technology and careful alignment.
- **Removal of exposed tags:** The RFID Tags cannot be concealed in either spine or gutter of the books and are exposed for removal. If a library wishes, it can insert the RFID tags in the spines of all except thin books; however, not all RFID tags are flexible enough. A library can also imprint the RFID tags with its logo and make them appear to be bookplates, or it can put a printed cover label over each tag.

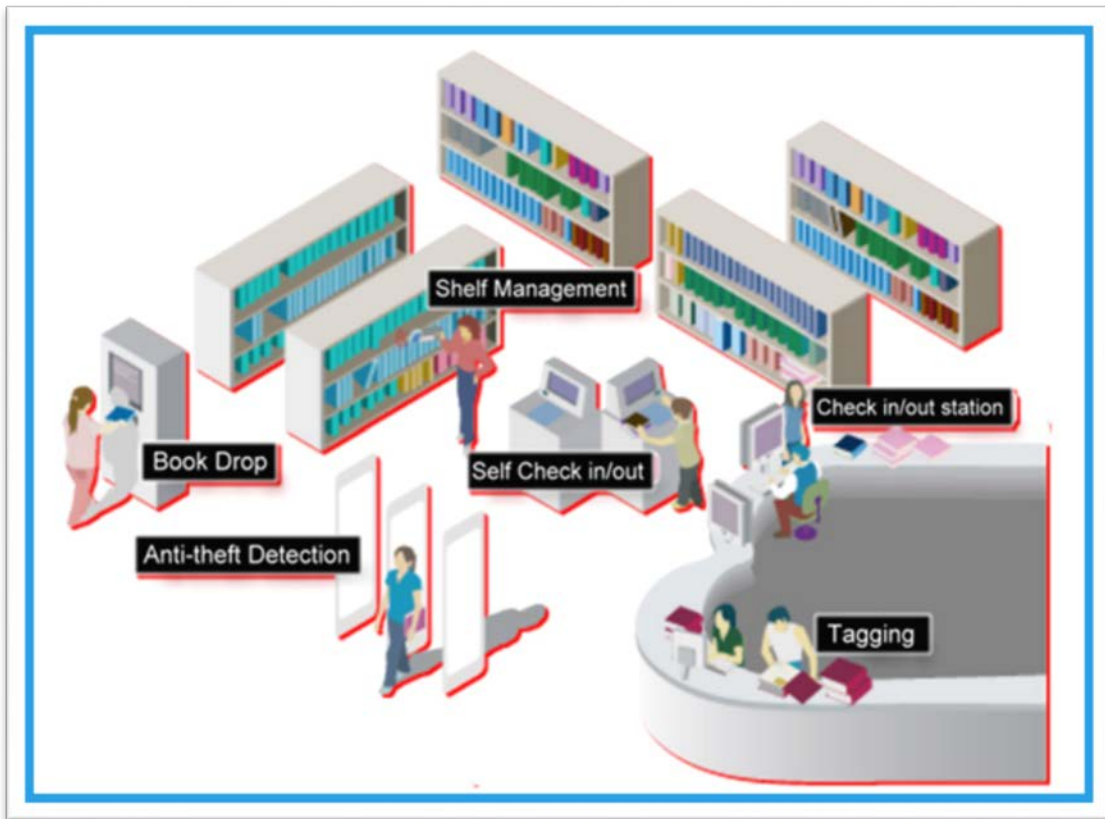
7. IMPLEMENTATION OF RFID SYSTEM AT CENTRAL LIBRARY, IIT MADRAS

RFID has implemented in Central library, IITM in 2004. The vendors M/s Edutech had implemented RFID in IITM in 2004 but after 2011 onwards Central library, IITM deals with ST Logitrack Singapore. The VIRTUA (VTLS) LMS software used for RFID in IITM. The hardware used for RFID technology in IITM- 2 Book drop box, 3 self check out station, 2 inventory and 1 sorting station. Around 100000 books tagging were completed initial in 2004 through 5 trained staff of IITM. Now almost 4 lakhs books & more are tagging of RFID.

RFID technology is involved in various modules in libraries, such as tagging station to tag the RFID label to each library material; patrons self check-out station to borrow the books using the self service; book drop station is used to return the books; and anti-theft security gates ensure the items are checked-out before leaving the library by detecting if the RFID label that are attached in the item is activated; and finally as to the self management, for example patrons can track the searching items that were mis-shelved by the use of RFID handheld reader.

The main library adopts RFID technology aim of improving the self service. Patrons can borrow and return the items using automatic lending machines, which require a library smartcard and a PIN. Self service becomes much easier with this new technology. Besides,

sorting the returned books greatly reduces the library staffs manual work. As RFID label has anti-theft function; there is no need for an extra alarm strip to be attached to the item, which makes the borrowing and tagging tasks a lot easier accordingly. The whole system is very clearly shown in the below figure:



7.1 HARDWARE PRODUCTS

In this section, the hardware products based on RFID technology used in the IITM central library has introduced.

- **RFID Tags:** - RFID tags allow materials to be accurately identified and tracked. Specific object information is stored in the memory of tags and is accessed via the radio signal of RFID



readers. All materials are attached with 3M™ RFID tags. Tag model D7 is used for books, periodicals and videos, and tags model CD8 are applied to CDs and DVDs.

- **Table Readers:** - Table readers in libraries are mainly used for check-in/checkout units to achieve the fast and efficient reading functions. RFID table readers can read library cards through barcode or RFID chip, and it is possible to read max. 3 items at the same time within a range of 54.5cm length and 30cm width on the table reader. High Frequency 13.56 MHZ domain interface is used in Table Reader.



- **Handheld Readers:** - Handheld readers are applied with High Frequency 13.56 MHZ. The handheld device is light and its reading speed is fast and there is no angle restriction while reading. However, the reading distances are small; only one item can be read per time. Besides, misreading or disable reading can't be 100% avoided. Handheld readers are mainly used for shelving in libraries.



- **RFID Security Gates:** - RFID Security gates are used to detect RFID tags to ensure that all items leaving the library are checked out. Each library item is embedded in a RFID tag and the AFI (Application Family Identifier) status in the tag is activated until the item is checked out. The RFID tag triggers the alarm system if the AFI status is not deactivated. However, RFID readers may not be able to detect items if there are metals surrounded or tags embedded in items are being squeezed when passing by the security gate.



- ❖ **SIP2 Protocol** is a communication protocol that provides a standard interface between a library's integrated library system (ILS) and library automation devices (e.g., check-out devices, check in devices, etc.). The protocol can be used by any application that has a need to retrieve information from an ILS or process circulation transactions via the ILS. There are two versions of SIP, version 1.0 and 2.0. SIP2 is based on a

proprietary protocol, but has been opened for use by all parties providing systems for library circulation.

- ❖ **RFID Tagging Station:-**A tagging station consists of a network PC, reader and antenna. All library materials must be tagged and programmed and the tagging station is used to affix the tags to the materials and program them. As the system is now still barcode based in Central library, IITM thus RFID tagged items must connect to the system through barcode. To build the connections, first the staff station reader checks if the item that are on it has already RFID tag attached or not, and if it doesn't, attach it first, then the system will formulate the connection by using handheld reader to scan the item's barcode. After that, information can be added into RFID label using the system. And one RFID label can be used for only one item, so if the barcode destroyed, RFID label needs to be changed too. However, the library is planning to change the system from the barcode based to RFID based, which will achieve the inventory and localization functions in the near future.
- ❖ **Patron Self-Check-out Stations:-**The Self-check-out unit greatly improves customer service and increases operational efficiency while providing a strategic competitive advantage. The patron Self Check-out unit benefits both patrons and the librarian. To patrons, it reduces their time for waiting lines and provides them privacy. To librarian, they can be relieved from heavy work of daily routine so as to better service patrons. The Central library, IITM used ELiMS Self Check-out Station which is consists of a PC with a touch screen monitor, a built-in RFID reader, and completes with a receipt printer.

7.2 ABOUT ELIMS

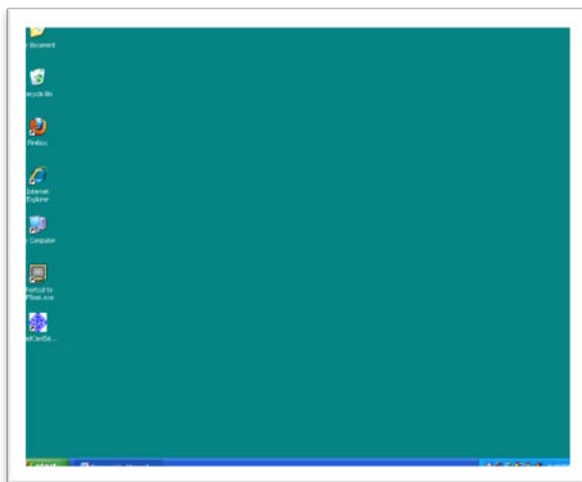
ELiMS® is the RFID- based Electronic Library Management System that is designed to manage the tracking, distribution, circulation and flow of library materials. It facilitates multiple, automatic object identification, tracking, sorting as well as speedier data collection, which tremendously improves the efficiency of libraries, thereby freeing librarians to provide other value-add services, such as assisting in library material search.

ELiMS[®] is a state-of-the art library automation system that caters to the needs of both library patrons and librarians. In its basic configuration, ELiMS[®] facilitates self-help as well as counter assisted check-outs and check-ins of all library materials such as print materials, CDs, video tapes and audio tapes. ELiMS[®] family of products has expanded to include auto-sorters, 24/7 return stations, smart dispensers and smart shelves. ST LogiTrackPte Ltd is the registered owner of the patent in many countries including Singapore, USA, Australia, Taiwan, Malaysia, Canada, Indonesia, Norway, Vietnam, New Zealand, Russia and Korea with the application pending grants in other countries.

7.3 PATRON SELF-CHECKOUT PROCESSES

Firstly, the patron chooses one service language from the touch screen monitor, and then the patron will be identified with a library card and its PIN code. After identified, the patron can place items to be borrowed on the reading table, and then the monitor shows the items status, borrowed or not. Once items are successfully borrowed, the receipt will be printed. However, the patron can always asks help from the librarian if they need guidance to get started of using the checkout unit or if some items cannot be read for some reason. The Self-check-out unit is easy to use as shown in below figure.

Data flow diagram, as shown below presents the whole self-checkout processes at Central library, IITM



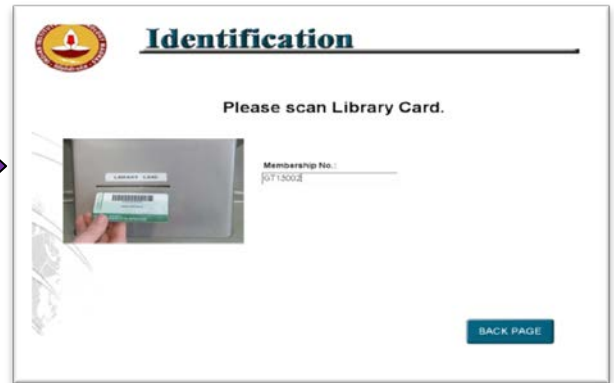
Here we get ELiMS software



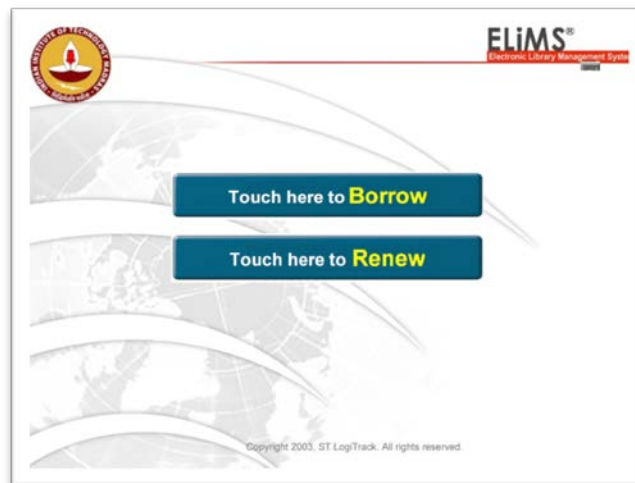
This is the home page of ELiMS Self check



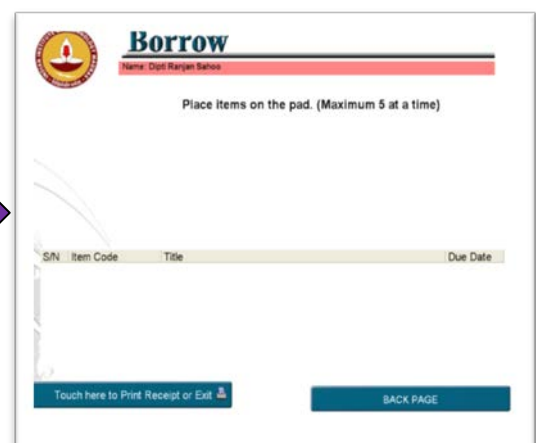
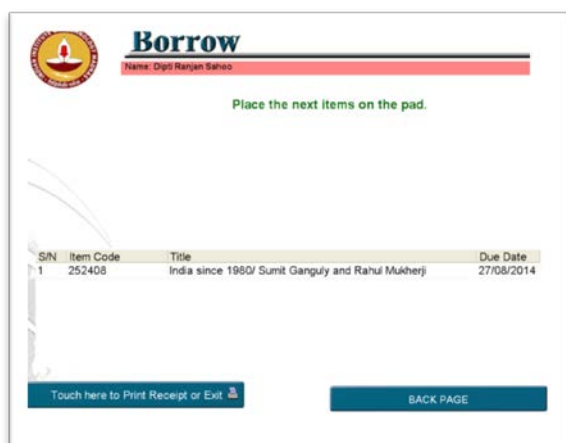
Here, we have to insert library card



Here, we have to give membership number



Here, we get two options:- Borrow & Renew



Hence, in this way the whole self-checkout process goes on.

7.4 SELF SERVICE CHECK-IN STATION AT CENTRAL LIBRARY, IITM

Check-in station consists of a PC with a touch screen monitor, a built-in RFID reader, and completes with sorters. The self-service check-in process basically works same as the self-service checkout process, but a lot simpler as identifying the library card step is not required. Items are reactivated security when returned and the returned information is shown in computer screen and receipt can be then optional printed.

8. CONCLUSION

Although, the RFID technology is quite expensive, still it has yielded excellent results for many libraries throughout the world. It has the capability of making the management processes in the library more convenient. The only barrier in the journey is high cost of it, but every new technology implementation somewhat dearer. Moreover, RFID applications lead to significant savings in staff costs, enhance service and provide efficient results, which leads to fool proof security and access control. It not only provides a constant update of library collections, proper holding management, but also accomplishes real-time services.

Developments in RFID technology continue to yield larger memory capacities, wider reading ranges, and faster processing. The interest in RFID as a solution to optimize further the automation and tracking of documents are gathering momentum at an increasing pace, with more libraries joining the trails. "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."

RFID offers considerable advantages in library management as compared to conventional bar codes and magnetic stripes. RFID technology at Central library, IITM is fully adopted so far such as intelligent inventory or tracking the books; etc. Around 100000 books tagging were completed in IITM.

In the future, it is expected that this technology will be adopted also in the book publishing industry, meaning that books are going to be tagged with RFID labels already before shipping

them to libraries. This will make RFID's future in library management more apparent and positive.

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