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RFID Technology for Libraries

I. Objectives

- Introduction To RFID
- Components of RFID
- RFID Use in Libraries
- Interfacing RFID with Library Automation System
- RFID Standards (NCIP 2.0 and SIP2)
- Advantages and disadvantages of RFID

II. Learning Outcomes

After completion of this lesson, learners would develop understanding about RFID technology, its components, RFID standards and protocols, its advantages and disadvantages.

III. Module Structure

1. Introduction
2. What is RFID?
3. Origin of RFID
    - 3.1 Components of RFID
        - 3.1.1 RFID Tags
    - 3.2 RFID Readers and Server
        - 3.2.1 RFID Readers and Server
4. RFID Use in Libraries
    - 4.1 RFID Tags in Libraries
    - 4.2 RFID Readers in Libraries
        - 4.2.1 Staff Station (Conversion Station)
        - 4.2.2 Self Check-in/ Check- out Station
        - 4.2.3 Exit Sensors (Security Gates)

1. Introduction

Today, more and more libraries are adopting RFID (Radio Frequency Identification) technologies as it streamlines workflow in the area of self-service, book returns, shelf management and inventory. In this module we will be studying the basics of RFID technology with glimpse on components of RFID, learners will also be provided details on RFID technologies which can be used in Library, RFID standards and protocols for libraries, and the potential advantages and disadvantages of using RFID in libraries.

2. What is RFID?

Radio-frequency identification (**RFID**) is part of family of AIDC (Automatic Identification and Data Capture) technologies that includes barcodes and smart cards, it is non-contact (wireless) use of radio-frequency electromagnetic fields to transfer data, for the purposes of automatic identification and tracking of tags attached to objects. The tags contain electronically stored information which can be read, added or modified. These tags doesn't need to be in line of sight of the reader and can be embedded in variety of objects.A tag is

constructed of a silicon microchip and is etched with an antenna.

3. Origin of RFID

Discovered in 1935 by Scottish physicist Sir Robert Alexander Watson-Watt, the first known application of RFID was done in World War II where in RFID was used to identify the planes (enemy or own) using radar. Advances in radar and RF communication systems continued through the 1950s and 1960s. Scientists and academics in the United States, Europe and Japan did research and presented papers explaining how RF energy could be used to identify objects remotely. Companies began commercializing anti-theft systems that used radio waves to determine whether an item had been paid for or not. Electronic article surveillance tags, which are still used in packaging today, have a 1-bit tag. The bit is either on or off. In 1970s Los Alamos National Laboratory (United States) had developed a system for tracking nuclear materials, where in the concept was to put a transponder in a truck and readers at the gates, the gate antenna would wake up the transponder in the truck, which will respond with the data. Later (in Mid 1980s) this system was commercialised for automated toll payment systems.

Los Alamos National Laboratory (United States) also developed a passive RFID tag to track domestic cattle to maintain their health data. This system used UHF radio waves, which drew energy from a reader and reflect back a signal modulated with data using technique known as backscatter. More advances in technologies led to low frequency(125 kHz) reducing transponder size in such a way that it can be encapsulated and injected in to cattle skin, this low frequency transponders can also put in the cards which can be used to control access.

Over the time, the radio spectrum was moved up to high frequency (13.56 MHz) to cater higher range and faster data transfer rates, currently 13.56 MHz RFID systems are used for contact less (smart) cards, NFC, access control and tracking, anti-theft devices, etc. IBM developed and patented ultra-high frequency RFID (UHF), which offered longer read range and faster data transfer.

Funding from Uniform Code Council, EAN International, P and G and Gillette to Massachusetts Institute of Technology for establishing Auto-ID Centre boosted the UHF RFID technology in 1999, this initiative was to put low-cost RFID tags on the products and to track them through supply chain. The idea was to put only Identification number on the tag which will reduce the memory requirement of RFID chip and put all relevant data associated with that identification in a network accessible database. Between 1999 to 2003 Auto-ID Centre of MIT gained support of more than 100 large companies, US Department of Defence and many RFID vendors where in it developed two “air

interface" protocols (Class 1 and Class 0), the Electronic Product Code(EPC) numbering scheme, and a network architecture for looking up data associated on anRFID tag on the Internet. The technology was licensed to the Uniform Code Council in 2003, and the Uniform Code Council created EPCglobal, as a joint venture with EAN International, to commercialize EPC technology. The Auto-ID Center was closed in October 2003, and its research responsibilities were passed on to Auto-ID Labs. EPCglobal ratified a second-generation standard in December 2004, paving the way for broad adoption.In 2010, three key factors drove a significant increase in RFID usage: decreased cost of equipment and tags, increased performance to a reliability of 99.9% and a stable international standard around UHF passive RFID.

3.1 Components of RFID

Generally RFID system consist of an object (i.e. an item which needs to be identified or tracked) with a tag, a RFID reader to read data from the tag. A server or a docking station with software that interface with a system that makes use of information from the tag.

3.1.1 RFID Tags

These tags mainly are of two types: active and passive.Active tags can be powered and read at short range via electromagnetic induction (magnetic field). Passive type of tags can use local power source (a battery) or can collect energy from the surrounding electromagnetic field and act as passive transponder to emit microwaves or UHF radio waves.
Passive tags don't have any energy supply of its own, so it cannot generate radio wave itself, whereas active tags have an energy source and can generate radio waves on its own and can transmit the data available in the chip.

Again active tags can be of two types, first type contains a transponder which can be activated by some sort of signals from readers, whereas another type emits radio waves at a specified time intervals. Passive tags tends to be cheaper and smaller than active tags.

The operative frequencies of Active RFID tags are 455MHz, 2.45MHz, or 5.8GHz, due to these high frequencies tags can be read at distance of 18 to 90 mts. This feature makes application of active tags in warehouses, factories,

shipping terminals etc, additionally it can contain quite a large information on chip

	LF 125 KHz	**HF 13.56 MHz**	**UHF 868 - 915 MHz**	**Microwave 2.45 GHz and 5.8 GHz**
Typical Max Read Range	< 0.5 m	~ 1 m	~ 3 m	~ 10 m
Tag Type	Passive	Mainly Passive	Active and Passive	Active and Passive
Tag Power Source	Generally passive tags only, using inductive coupling	Generally passive tags only, using inductive or capacitive coupling	Active tags with integral battery or passive tags using capacitive, E-field coupling	Active tags with integral battery or passive tags using capacitive, E-field coupling
Data Rate	Slower	Medium	Fast	Faster
Ability to read near metal or wet surfaces	Best	Better	Worse	Worst
Tag Size	Larger	Larger	Smaller	Smaller
Tag Cost	High	Lower then LF	Lowest	High

Table 1: Operating Frequencies and Performance Characteristics of RFID Tags

Passive tags can transmit on low, high, or ultrahigh frequencies. Passive tags used in libraries tend to operate at the high, 13.56 MHz, frequency and therefore the distance that these tags can communicate with the reader is limited to a few centimetres to a few meters, which is what is needed in a library setting. These tags cost from £12.00 to £.0040n an average.

3.2 RFID Readers and Server

3.2.1 RFID Readers and Server

Another part of RFID system is the reader, or sensor. Readers operate on same frequency as of tags. The antenna available in reader emits electromagnetic field

and tag picks up this field and draw energy from it, the tag uses this energy to activate the circuit (and the chip) available on it , while doing this process the electronic ‘state’ of the antenna on the tag changes. The reader’s antenna detect this ‘state’ change and convert it into the binary information (i.e. the signal emitted by tag). This information is sent to the third part of the RFID system, the serverfor processing. The software on the server contains the further information about the unique identification information held on the tag.The server uses this identification number to track the item, or record the items movements.

4. RFID Use in Libraries

Libraries around the world have already started to use RFID technologies for speedy and efficient handling of library object, inventory control, and check-out, check-in process. In general the technology used in libraries is the same technology used in applications of passive RFID tags.

The main objective of application of RFID in libraries is to increase efficiency and reduced cost. Automation of day to day functionalities and self-service can help libraries for smoother functioning. It also enhances security of library materials.

4.1 RFID Tags in Libraries

Tags can be Read Only (RO), Write Once Read Many (WORM) or Read Write (RW).RO tags are preprogrammed with a unique number like a serial number (or may be accession number/ ISBN number). WORM tags are pre-programmed but additional information can be added to tags. RW tags canbe updated dynamically. Most library applications use RW tags.

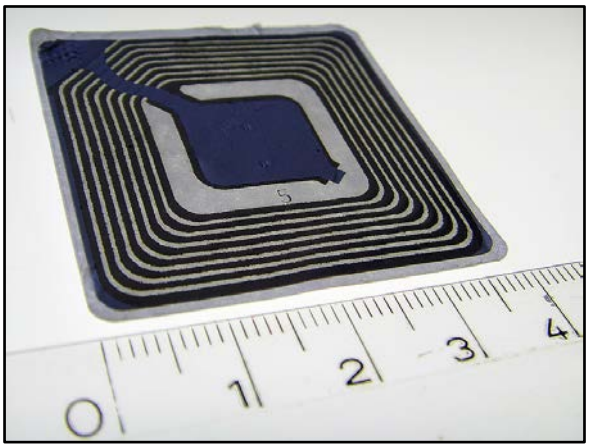

Fig.1: RFID Tag

US based National Information Standards Organization (NISO) in its document "RFID in US Libraries" (NISO-RP-6-2012) released in March 2012 has made following recommendations for RFID tags to be used in libraries.

- In Libraries, 13.56MHz High Frequency tags should be used;
- RFID tags for library use should be passive;
- The typical read range of tags for library applications should not be increased substantially beyond the present range of 8-20 inches for smaller tags in future;
- Only tags including standardized AFI feature should be used in libraries;
- The system will cause no interference with other applications;
- The system will utilize ISO/IEC 18000-3 Mode 1 tags programmed so that they should work for identification of items in other libraries;
- The system will use tags that will not interfere with the operation of security systems in other libraries;
- Security implementations for RFID in libraries should not lock a compliant system into any one security possibility (EAS, AFI, Virtual deactivation), but rather leave security as a place for differentiation between vendors;
- RFID tags should be reprogrammable for migration purposes; and
- Data on RFID tags should be encoded according to the recommended data model, using encoding described in ISO/IEC 15962 and using relative object IDs specified in anticipated standard ISO/NP 28560 for RFID in libraries.

4.2 RFID Readers in Libraries

RFID readers mentioned below are required in library for the typical RFID implementation.

4.2.1 Staff Station (Conversion Station)

Library staff station unit enables library staff to check-in or check-out items for library circulation operations, This unit also enable library staff to tag a particular item (library item or member card). It can be connected to existing hardware (PC) as a standalone solution.

Fig.2: RFID Staff Station

4.2.2 Self Check-in/ Check- out Station

RFID self-check-in/check-out systems provide facilities for borrowing, return and renewals of materials via RFID tags. RFID self-check systems can safely check-out library items in one easy step by just putting the material on the station. In the station, when the RFID tag is read, a software eventoccurs which changes the status of the item either checked-in or checked-out based on the operation performed. Modern check out stations also prints receipt informing the user when to return materials to the library. Self service station can be used to check in library materials without staff assistance, where in user can directly put in his/her borrowed material.

Fig.3: Self-Service Station

4.2.3 Exit Sensors (Security Gates)

Exit sensors or security gates can be used to verify that all material leaving the library has been checked out. Generally a security Gate is composed of two pedestals, additional pedestals can be added for increased detection surface. Each pedestal is standalone and plug into the main power. This exit sensors can be a standalone solution or may be interfaced with library management system.

Fig.4: RFID Gate

4.2.4 Book-drop Station

Book-drop stations are used to automatically discharge library materials and reactivate security. This station can be placed anywhere, within or outside the library. Library user drops the library item (book or any other material) into the slot. The reader captures the electronic signature on the RFID tag and sends to backend system for appropriate action. User is also acknowledged by alerting sound, light or printed receipt. Library user's record is updated immediately in the library management system.

Fig. 5: Book Drop Station

4.2.5 Sorter and Conveyor

Sorter and conveyor are combination of automated system for returning material to proper area of library. When the library material is returned by the user by any means, it is usually placed on a conveyor which carries the item at designated location, a scanner placed at location reads the tag and decides the exact bin, where it has to be placed or dropped, when the item reaches to the correct bin it is automatically dropped to the bin using mechanical system. If the item is reserved by someone it will get dropped to a bin designated for reserved items.

4.2.6 Hand-held Reader

The portable handheld reader can be moved along the items on the shelves without touching them. The data captured by this unit can be stored in the unit itself, which can be downloaded through a software interface or it can be transmitted via wireless connection to the server. This handheld reader can be used for inventory control (including stock verification), to locate mis-shelved library item, or tracking of library material.

Fig. 6: Handheld RFID Reader

4.3 Interfacing RFID with Library Automation System

The server is the heart of comprehensive RFID systems. It is the communication hub between various components of RFID. It receives the information from the readers and exchanges information with the library automation system database. The standard server softwareincludes the NCIP (National Circulation Interchange Protocol) or SIP/SIP2 (Session Initiation Protocol), APIs (Applications Programming Interface) which are necessary to interface it with the integrated library software. The server typically includes a transaction database so that reports can be produced. Most of the LMS vendor supplies this

RFID server (or middleware) at additional cost, whereas SOUL 2.0 (LMS developed by INFLIBNET Centre) comes packaged with RFID Server.

4.4 RFID Standards For Library

4.4.1 NCIP (National Information Standards Organization Circulation Interchange Protocol)

This is a protocol that provides specifications for the exchange of messages between and among computer-based applications to enable them to perform functions necessary to lend and borrow items, to provide controlled access to electronic resources, and to facilitate cooperative management of these functions. The first edition of the NCIP (NISO Circulation Interchange Protocol) standard (version 1.00) was published as ANSI/NISO Z39.83 in 2002. It was then revised in 2008 (version 2.00) to include greater extensibility, improved self-service and error handling, and to address issues that surrounded the first version of the standard. In 2012, a new revision (version 2.02) was approved and published.
This protocol defines a collection of messages and associated rules of syntax and semantics for use by applications; to perform the functions necessary to lend items; to provide controlled access to electronic resources; and to facilitate co-operative management of these functions. It is intended to address conditions in which the application(s) that initiate the lending of items or control of access must acquireor transmit information about the user, items, and/or access that is essential to successful execution of the function.

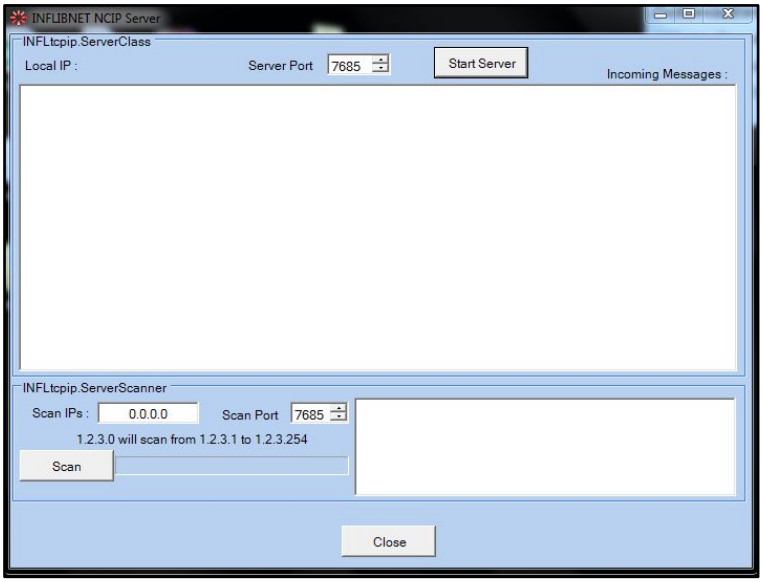

Fig.7: SOUL 2.0 interface for NCIP Server.

4.4.2 ISO 180003- Mode 1

This is an ISO standard for parameters for air interface communications at13.56 MHz (High Frequency), based on which RFID hardware is being developed for usage inLibrary. The standard defines communication parameters on which the tag and readercommunicates with each other.

4.4.3 ISO 28560-1:2011

This is a set of Information and documentation — Data model for use of radiofrequency identifier (RFID) in libraries. ISO 28560-1:2011 specifies a model for the use of radio frequency identification (RFID) tags for items appropriate for the needs of all types of libraries, including academic, public, corporate, special and school. This standard provides the framework to ensure interoperability between libraries in exchange of library items with RFID tags, the freedom of the library to acquire or renew equipment or library items from different vendors and interoperability of a single RFID application from the vendor's perspective's 28560-1:2011 specifies a set of data elements and general guidelines for implementation, to meet the needs for circulation, acquisition, Inter library loan process, data requirements of publishers, printers and other suppliers of library items; inventory and stock checking of items. ISO 28560-1:2011 gives guidelines for item security, profiles, privacy, implementation, migration, label design and location of the RFID label.

4.4.4 SIP2 Protocol

SIP2 Protocol is a communication protocol that provides a standard interface between Library Management System (LMS) and library automation devices (For Example, staff station, check-out and check-in devices)the protocol can be used by any application that has a need to retrieveinformation from an LMS or process circulation transactions via the ILS. There are two versionsof SIP, version 1.0 and 2.0. SIP2 is based on a proprietary protocol, but has been opened foruse by all parties providing systems for library circulation.

4.5 Advantages and Disadvantages of RFID in Libraries

RFID use can be a debateable topic when libraries choose to convert their collections to be able to take advantage of the technology. There is little doubt that maturity of RFID technology, however, a library should balance the advantages and disadvantages. Many of the advantages of RFID revolve around

the day to day use in libraries and using the technology for more and more automated procedures and to free up librarians for more productive work where as many of the disadvantages revolve around the technology itself, but include issues surrounding security and privacy.

4.5.1 Advantages

i. Reduction of Manpower Requirement: Use of RFID technology in a library candrastically reduce the time, being spent on circulation tasks, as RFID technology enables reading of more than one tag at a time. Self service station can also attribute to free up man hours from this tasks. The stock verification and other inventory control operation using RFID based handheld reader can be finished in very less time compared to traditional approach. Conveyor belts and sorting systems can reduce time that staff spend shelving returned items because the items can be pre-sorted.

ii. Reliability: Correctly operating readers and tags can have near 100% detection rates. Since the tags and sensors communicate with the Library Management System (LMS) it is possible to know exactly which items are moving out of the library. The high reliability is especially important when RFID is used in theft detection.

iii. Security: RFID security and the tracking of materials throughout the library overcomes the problem of theft in the library. It is a dual system that uses tags for security as well as tracking and handles both simultaneously with a single piece of equipment. RFID systems encode the circulation status on the RFID tag. 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. If the material that has not been properly charged is taken past the exit sensors, an immediate alarm is triggered. Another option is to use both the “theft” bit and the online interface to an automated library system, the first to signal an immediate alarm and the second to identify what has been taken.

iv. Better Inventory Control: As stated earlier, RFID systems are having ability to scan library items on the shelves without tipping them out or removing them. A hand-held 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.

v. Tag life and appearance: RFID tag life is said to be 100,000 transactions or at least 10 years. These tags do not interfere with the appearance of the book, and can even be made to appear as a bookplate.

4.5.2 Disadvantages

i. Cost: The major disadvantage of RFID technology is its cost. RFID is not an inexpensive technology. Apart from tags (12.00 to 40.00) for each library item one also needs to consider costs of self-service stations, staff readers, security gates, and hand held devices as well as cost of implementation in terms of fixing of RFID tags for each item as well as installation and integration of all equipment etc.

ii. Vulnerability: It is possible to tamper an RFID system by wrapping the metal (or aluminium) 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 overlaps another, this maynullify the signals. This requires careful alignment while tagging.

iii. Removal RFID Tags: The RFID tags usuallycannot be concealed in either spine or gutter of the books and are exposed for removal. 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.

5. Summary

In this module, we have learnt basics of RFID technology along with components, standards and protocols related to implementation of the same in the library. It is quite clear from the above discussion that an RFID system may be a comprehensive system that addresses both the security and materials tracking needs of a library. RFID in the library is not a risk, if the standards are followed religiously, RFID speeds up circulation operations of a library along with faster in-house operations related to inventory handling and frees the library staff to do more productive work.It is important to educate library staff and library users about RFID technology before implementing RFID System in the library.

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