Implementation and integration of radio-frequency identification system: a practical approach

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1. Introduction

Radio frequency identification (RFID) is an automatic identification technology that is used to track items by sending data to readers through radio waves. RFID tags provide information on the items to identity, activity, location, and data stored inside through readers and application software is used to make the information useful for security. Library management system includes areas such as circulation, cataloging and barcoding have direct effects on users satisfaction. RFID was introduced in the late 1980s, and RFID tags and readers have gone down quite a bit, making this technology available to a broader market.

RFID is a grouping of radio frequency–based technologies in which the information is contained on chips in tags affixed to library resources. This RFID technology is basically used for Issue and Return, which is normally called staff station readers while the ones used at building departures are usually called sensors. An RFID tag is mostly thin, flexible and smooth, with remote induction technology, to fit in with the information system to record patrons' loan history, improve the efficiency of library inventory and strengthen circulation and safety management (Kern, 2004). Currently, this has been the majorly used in Library Environment to replace traditional method which is basically called barcode and magnetic tape with wireless technology (Yu, 2007).

Migrating from the old barcode management system to RFID technology is a more reliable, effective, real-time and scalable library data management system. RFID produces a solution in managing, collecting and distributing books effectively (Lau *et al.*, 2008). It outperforms the barcode system because line of sight is not a requirement. Currently, many libraries are equipped with high frequency (HF) RFID tags and readers operating internationally at a frequency of 13.56 MHz (Bansode and Desale, 2009). The advantage of the 13.56 MHz operating system is that the frequency is available in most countries. This frequency has been reserved for industrial, scientific and medical applications. However, the ultra-high frequency (UHF) RFID system surpasses this efficiency by increasing the reading range and providing multi-reading capacity compared with the HF RFID system in library automation systems (Molyneux, 2011) (Table I).

Library data management systems can implement quick shelving of books using the UHF RFID technology so that any misplaced items can be detected easily using portable readers. The capability of the UHF RFID to read multiple tags simultaneously with lesser distortion error compared with the HF RFID technology facilitates book inventory applications. UHF RFID is more efficient for implementation for security gates because of its capability to detect a tag in a longer range than HF RFID. The incremental utilization of UHF tags in the logistics and retail industries has brought down the cost of the UHF tags over the years. Comparing HF RFID and UHF RFID tags, the HF tag is complex with multi-turned coils, whereas the UHF tag is small and has a single turned and single-layer loop antenna. Therefore, the pervasive use of the UHF RFID tags results in a lower manufacturing cost (Figure 1).

It is enterprise software that finally uses the data captured by the readers and uses the information to provide real-time visibility to the process using the Koha online public access catalogue (OPAC). In some cases, RFID middleware is developed, which lies between the hardware infrastructure and the software application as a common interface that manages data flow between the two and manages the hardware infrastructure. In this case, Avior technologies has developed middleware for the Central Library. RFID middleware software integrated with Kiosk Machine for issue return through this Kiosk machine user can issue and return by self's and RFID middle ware software also integrate with Gate and Staff Station for controlling the Hardware devices. Middleware software carries out the work like check-out, check-in, book detail searching, patron details, RFID tagged books, link reader etc. This software is based on Perl language with SIP2 and NCIP base system, which is very helpful for integration with any Integrated Library Management System software. After receiving data from the user interface, this tier:

- Formats data as per the software protocol of the RFID reader and communicates to the reader;
- Send queries to the Koha database; and
- Update users' with their data.

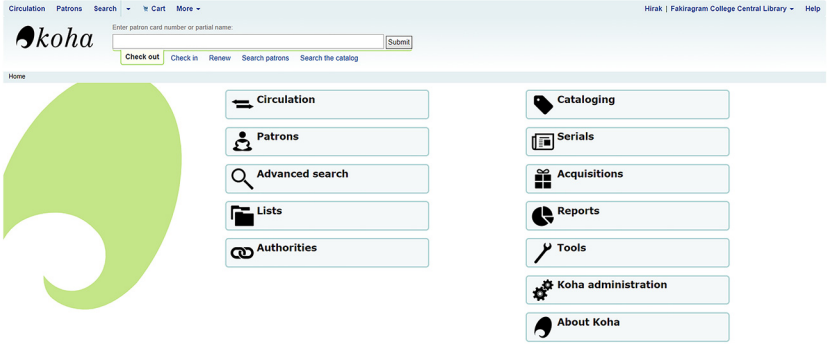
In the third tier, there are two applications: the first one is the RFID reader and the second one is the Koha MySQL database. The reader does all the communications with the tags by sending appropriate ISO15693 supported commands (Figure 2).

The RFID tag is made up of a microchip with a unique identification number and the antenna to be able to transmit these data to the reader wirelessly. RFID tags have high data

Table I.
Types of RFID systems

Frequency	Characteristics	Applications
125 KHz – 135 KHz Low Frequency	Good performance around the metal and liquid Slow data transfer rate Few inches of reading range	Access control Animal identification
13.56 MHz High Frequency	Worldwide standards Longer read ranges than LF Tag cost lower than LF Poor performance around metal and liquid	Library Access control Asset tracking Smart shelf People identification Item level tracking
433MHz and 860MHz to 930 MHz Ultra-High Frequency	Longer read ranges than HF Used as Active RFID systems Most widely accepted frequency in supply chain mandates Volumes may bring the tag cost to lowest when compared to others Poor performance when near metal and liquid	Supply chain management Inventory control Warehouse management Logistics Asset tracking Library
2.45 GHz and 5.8 GHz	Fast data transfer rates Used for active and semi-active RFID systems Poor performance when brought near metal and liquid	Toll collection Industrial automation Fast moving conveyor belts

Figure 1. *Koha library OPAC interface*



capacity and can include manufacturer, batch number, ownership, destination, history etc. depending on the application needs. The amount of storage available on the tag ranges from 16 bits to as high as several thousand bits. Tags with assimilated circuits are the most used systems and are composed of an antenna and an integrated circuit. Nikitin *et al.* (2010) describe spatial identification (determining position and velocity) of modulated backscatter UHF RFID tags using RF phase information. There are three categories of RFID tags.

Passive tags only backscatter magnetic or electromagnetic waves coming from the interrogator. That is the only way they can communicate with the interrogator. In other words, they do not have any RF emitters on board, so they cannot create their own RF signals. Battery-less passive tags use the incoming signal from the interrogator to supply the embedded chip. Battery-less and passive are two different characteristics of the tag and are unfortunately often confused.

Battery assisted passive tags (rechargeable or not) supply internal circuitry or connected sensors or actuators. This power source is not used to create an RF signal because the tag is always passive (backscatter only incoming RF signal from interrogator).

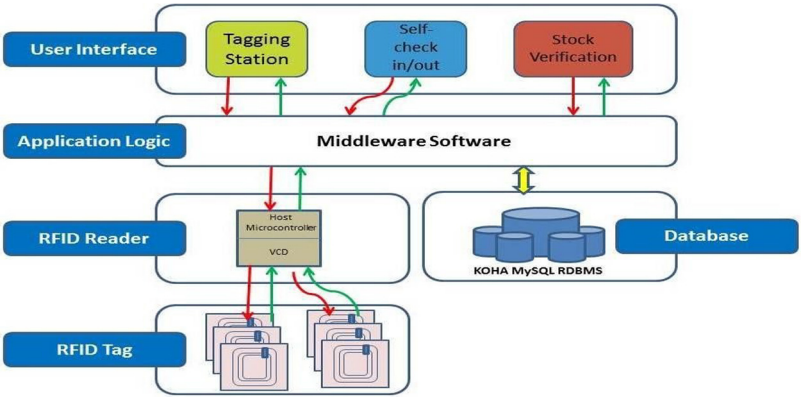
Active tags have their own RF emitter on board. They can either send RF signals to the interrogator as they receive a comprehensive command or function without any external command (they act as an RF beacon). Because creating an RF signal requires a lot of energy, active tags quite often have an internal (embedded) power supply. This means they are often confused with battery-assisted tags.

The tag is paper thin and flexible, which permits it to be placed unremarkably on the inside cover of each book in a library's collection and user's library smart card. It consists of an etched gate and a tiny chip, which stores vital bibliographic data including a unique ID number to identify each item. This contrasts with a barcode label, which does not store any information, but merely points to a database. RFID tags can be either active – having their own battery power source – or passive – having no power source of its own (Strickland and Hunt, 2005; Ward, 2003).

The RFID reader, which is also widely known as an interrogator, sends an RF signal to request a tag for transmitting information within the chip. The response received from the tag is then translated into digital form and sent to the application software. Different types of readers are fixed readers, handheld readers, network readers, readers embedded in other mobile devices, etc.: (Kwon *et al.*, 2008) describes a single-antenna low-power single-chip RFID reader for mobile phone applications. RFID reader units become increasingly important with the adoption of passive UHF RFID systems in the supply chain, warehouse and retail store management (Ukkonen *et al.*, 2007). The design and evaluation of a flexible UHF RFID reader that enables new PHY/MAC designs are prototyped and evaluated (Buettner and Wetherall, 2011).

UHF readers in a library include staff workstations for circulation desk charging

Figure 2. *Integration of RFID middleware with Koha ILS*



and discharging and longer-range walk-through exit sensors to detect and read an RFID tag passage for purposes of determining whether it is a charged or discharged. Circulation includes check-out, check-in and renewal of the documents. It generally takes 10 to 15 min to complete a single operation when the task is performed manually, whereas the same transaction takes place within 1 to 2 s with the RFID system. A further benefit is that if the user has five items to check-out or check-in, the transaction can be easily completed within a single stroke. It also shows that five documents can be charged or discharged in one click. The same number of transactions takes 30 min when performed manually, whereas barcode-based systems take around 15 to 20 s for one transaction.

With a barcode system, the circulation staff have to scan the barcode of the user's card and then the barcode of every item to complete a single transaction, whereas using RFID, five transactions are possible in one click. This has resulted in saving the time of the users at the circulation section and also save the time for the library staff. These kinds of technology follow forth law library science "Save the time for User." Circulation using RFID with that of a manual and barcode system has become much faster than any previous system by those implementing RFID.

In security gates, the antenna transmits an electromagnetic field, which activates the tag. The antenna also receives the data from the tag and sends it to the reader. The RFID tag also has an antenna, which receives the required power from the electromagnetic field and transmits the data. Tags also require an antenna to transmit the information to the reader and to receive information from the reader if it is a rewritable tag. UHF-band RFID system handling many RF tags has some advantages over a bar code system such as simultaneous multi-reading and long read range. Method of tag movement direction detection using the difference of passing the time of two antennas without external expensive sensors is proposed (Oikawa, 2009, p. 12).

RFID security gates have been fixed at the entry and exit gates of the library. These gates are independent of each other and also have overlapping protection zones providing additional security. Any item that has not been checked-out is detected as it passes through the platforms.

An RFID kiosk is a plug and play multi-protocol reader system specially designed for library applications. The system has a touchscreen monitor and offers step-by-step instructions to guide patrons through the checkout process of all library materials including books, CDs, and DVDs. The system is compatible with all ISO standard RFID labels and operates seamlessly with the library applications. This unit programs and re-programs the RFID tags. Users need to search the book in the OPAC, note down the call number and bring it from the shelves. Put your ID card first on the deck; it will open the issue/return interface. Then remove your ID card and put the book on the deck and click on the tag when during check out and return. After issuing the book(s) take the printed slip and submit it at the security counter. After check out the user can exit from the library without any counter checking the security staffs and RFID Kiosk Machine provide fast and easy way to issue or return service during library opening hours.

Concluding remarks

RFID is not a new concept of the library environment. Koha and open source OPAC software is open to all types of changes, which is the real advantage when we are dealing with new technologies. Library staff hours essential to perform all these jobs are now being reduced and being utilized for providing some extra services. Most importantly the system has already put a check on the theft and misuse of documents, as users understand that the system is in place and capable of detecting theft.

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