

INTRODUCING RADIO FREQUENCY IDENTIFICATION (RFID) FOR IMPLEMENTATION IN LIBRARIES IN NIGERIA

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Abstract

Noting that libraries have evolved from being mere stacks of small amount of collections to enormous holdings of book and media related materials, this paper blended researchers' experience with available literature to introduce a new technological trend called radio frequency identification (RFID) to libraries. As an efficient technology that ensures security control, effective shelf management, and speedy circulation services in libraries, the paper highlighted the components of RFID as a library management system, and sequentially explained how to implement it in libraries. Whilst acknowledging the vulnerability and possible removal of RFID tags from library materials as an obvious drawback for the RFID technology, this paper recommended four ways to overcome the drawback and maximize RFID technology in libraries.

Keywords: Radio Frequency Identification, RFID technology, RFID library management system

Introduction

Leveraging technologies to optimize access and use of resources, increase customer satisfaction, facilitate inventory management, and control theft of resources are obvious contemporary needs across goods and service delivery industries, warehouses, shopping malls, large supermarkets and libraries worldwide. To this effect, a couple of technologies have come to stay, cutting across LiFi technologies, warehouse management software, Blockchain, Barcode systems, and now, RFID (Pin, 2019).

Over the years, libraries have evolved from being mere stacks of small amount of collections to enormous holdings of book and media related materials. Nowadays, the collection

size of most libraries, especial of public and academic libraries, run into tens and hundreds of thousands (Rahaman, 2016). As such, some specific library jobs like stock taking, circulation and tracking, and collection security have become herculean tasks that respectively over-labour staff, consume staff and patron time, and leave libraries to continually suffer theft. For these reasons, there arises need to leverage the RFID technology which has proved to be an effective library management solution in the areas of library security control, shelf management, and circulation services (Feng, 2010; Zhang et al., 2019). This is the focus of the study.

The RFID Technology

The term RFID stands for Radio Frequency Identification. It is part of the family of AIDC Automatic Identification and Data Capture technologies that include barcodes and smart cards (MHI, n.d). RFID can be described as the non-contact wireless use of radio frequency electromagnetic waves to transfer data for automatic identify and tracking of objects that contain electronically stored information that can be read, re-written and or modified (Amsler & Shea, 2021). Interestingly, RFID embedded objects must not be in the line of sight to be read by the reader machine. The composition of a typical RFID system consists of Tag, Reader, Antenna, and Server.

RFID Tag: Amsler and Shea (2021) provide a holistic insight into RFID technology. The RFID Tag is core to the effective functioning of the technology. An RFID tag is a copper or aluminium-made sticking device affixed to an object or item that needs to be identified and read by an RFID system. RFID tags are made up of an integrated circuit (IC), an in-built antenna and a substrate. The part of an RFID tag that encodes identifying information is called the RFID inlay. RFID tags are mainly of two types, namely, the Active Tag and the Passive Tag. The

Active Tag are self-powered and able to generate its radio waves and transmit large amount of data through its chip. They have excellent frequencies and can be read up to a distance of 20 meters. They are a little larger in size and costlier as compared to Passive Tag, but rarely used for libraries. On the contrary, the Passive Tag receives its power from the reader machine antenna, whose electromagnetic wave induces a current in the RFID tag's antenna to emit Ultra-High Frequencies (UHF) radio waves. As Passive Tag has no energy supply of its own and thus, cannot radio-wave itself, they operate on moderate frequencies and can only be read by the reader machine at short distance of about 1 meter. The Passive Tag is suitable for the library system and is prevalent in most libraries across the globe.

Notably, information on RFID Tags can be: Read Only (RO), or Write Once and Read Many (WORM), or Read and Write (RW). Read-Only Tags are pre-programmed with unique number like serial number, accession number, or ISBN number. But Write-Once-Read-Many Tags are pre-programmed with additional information to allow additions to the Tags anytime. Whereas the Read-Write Tags are dynamic and updated automatically. But amidst these modes of information that RFID Tag can carry, most libraries around the world use the Read-Write mode of Tag, as against the Read Only (RO), or Write Once and Read Many (WORM) Tags (Amsler & Shea, 2021).

RFID Reader: The Reader, also called the Sensor, is designed to read the data from the tag that is attached to the object or item. Readers, fixed or mobile (handheld), use their antennas (inbuilt or external) to connect to the tags. They operate at the same frequency with the type of tag they read (Amsler & Shea, 2021).

RFID Antennas: RFID antennas are devices that are used in a specially designed wireless system that is made up of two major components, Tags and Readers. The Reader is a device that is typically made up of one or more antennas, serving the purpose of receiving and emitting radio waves to and from the RFID Tag (Amsler & Shea, 2021).

RFID Server: The Server refers to the computer network and the RFID software. This is the working station with a software that will interface with the system that makes use of information from the Tags. The software on the Server contains further information about the unique identification information already captured from the Tag. Thus, an RFID Server, also known as the backend database, uses the identification number to track or record the movements of the tagged objects and items (Amsler & Shea, 2021).

Uses of RFID in Libraries

RFID technology has found widespread use in libraries around the world, transforming the way library materials are managed and improving overall operational efficiency. Areas of RFID application in libraries and best practices have been reported in literature. According to Ayre (2014), RFID enhances automated check-in and check-out of library resources. He stated that RFID tags are attached to library materials and when patrons want to borrow them, they simply place them on an RFID-enabled self-checkout station which uses RFID readers to scan the tags and record the borrowed items and automatically update the library's database. This process reduces the need for manual check-ins and check-outs, making transactions faster and more efficient.

In the words of Molnar and Wagner (2016), libraries often use RFID for inventory control as RFID readers moved across shelves can quickly scan the tags of books or other items,

allowing staff to perform regular inventory checks without physically handling each item. This helps identify misplaced or missing materials and ensures accurate collection records. They equally stated that RFID tags can be used for security purposes to prevent theft or unauthorized removal of library materials as each item is equipped with an RFID tag that is deactivated at the checkout counter. If a patron tries to leave the library without properly checking out an item, the RFID system will trigger an alarm, alerting staff to the potential theft.

In the same vein, Koppel (2013) opined that RFID is applied in the area of book sorting and shelf management. He buttressed that RFID technology can streamline the re-shelving process in libraries as RFID-enabled book drops can automatically identify and sort returned items based on their RFID tags, ensuring they are placed in the correct location. This reduces the time and effort required by staff to manually sort and re-shelve materials. He further inferred that RFID ensures quick search and retrieval of library resources as RFID readers can be used to scan shelves and quickly identify the presence or absence of specific books or other materials. Additionally, it can also be used to improve accessibility for visually impaired patrons as RFID-enabled audio labels or guides can be attached to shelves, helping individuals navigate and locate specific books thereby saving time and improving overall user experiences.

Requirements for RFID Installation in Libraries

As can be noted in available literature (Abdullah et al., 2011; Gupta & Madhusudhan, 2017), libraries around the world are already using RFID technology to facilitate security control (detecting theft through exit checks and tracing of missing materials), efficient shelf management (enhancing stock taking, shelve reading and book search) and speedy handling of circulation

services (charging and discharging of library materials). A typical RFID installation in library will require:

1. Server room to house the RFID host computer and network.
2. A Staff station where Circulation staff can check in or check out items for library circulation operations. This unit also enable Circulation staff to tag library materials and member cards. This set-up can either be connected to existing hardware or can be a stand-alone solution.
3. A self-check-in and self-check-out station to, alternatively, provide facilities for patrons' borrowing, return or renewal of library material via RFID tags. This kind of system can check-out materials in one easy step of putting the material on the station, to read the RFID Tag, pop up a software event interface, showing check-in or check-out, for the library client to select according the operation required. So, the self-check-in, self-check-out station can be used to check-in library materials without any staff assistance. Users return their borrow books and the return operation will be performed automatically.
4. Exit sensors or security gates to verify that all the materials leaving the library have been properly checked out or not. In this architecture, an RFID Reader is embedded at security gate. A security gate is composed of two or more pass lanes. An exit sensor can also be a standalone library management solution or interface with existing library management system.
5. Handheld mobile Readers which a staff can portably move along the materials on the shelves without touching them, to capture data pertaining to the materials on the shelve. Such data can be downloaded through a software interface or sent to the server through a

wireless connection. The handheld reader is used for inventory control, including stock verification, tracking of library materials, and for locating mis-shelved library materials.

6. Book-drop stations, containing a box that automatically discharge and reactive security on library materials. Book-drop stations can be placed anywhere outside the library, maybe at strategic locations that library users can easily drop library materials they borrowed. The Readers embedded on the book-drop box will read the Tag on the book and transmits same to backend system for appropriate actions. When successfully read in seconds, the user is immediately acknowledged for a successful material return by an electronic voice responses or printout slip.

Step-By-Step Approach to Utilize the RFID Technology

At this juncture, it is important to outline the sequential steps to implementing RFID in libraries. The outline can guide librarians to understand what needs to be done to practically utilize the RFID technology in their libraries and how the hardware is installed. Thus, the followings are the successive step-by-step approach to setup an RFID library management system in a typical library.

Convince management to obtain approval and funding for RFID project: As the RFID management system is relatively costly, libraries need to secure funds that can acquire and implement the use of the technology in their libraries. Doing so requires the support of the parent body, since libraries operate and serve a larger institution. Therefore, librarians must first and foremost convince the leadership of the institution they serve on the need for the RFID system and thus secure approval and funding for the project.

1. **Contract an RFID Vendor:** Since RFID is a technology that librarians – who are not technologists by training – can leverage to provide efficient services to their user public, contracting experts to acquire and configure RFID technology to library use is paramount. An expert company that sells and install RFID is herein called RFID Vendor. An RFID vendor contract is a business agreement that defines the terms of supply and installation of RFID technology. The terms will include the brand and composition of the RFID to be supplied, the overall cost of the package, the delivery and installation charges, and the obligations of both parties in the contract. Consequent to agreement, supply will be made for the RFID technology with the required number of tags and components compactible to it. It is remarkable to note that till date there has not been any reliable and popular RFID vendor in Nigeria. Most of the popular RFID vendors are foreign companies.
2. **Discuss with the vendor’s project team and agree on mode of operation:** After sealing a contract with an RFID vendor to supply and install the RFID technology in the library, the next essential step for the library leadership is to agree with the vendor’s project team on what shall be the mode of services in the library during the RFID installation period. Because the tagging exercise takes time, depending on the number hands deployed to execute it, some pertinent questions that must be answered before activating the RFID technology include: How long will the RFID system installation last? Will the library gate be closed to patrons during installations? Can some sections of the library operate while RFID installation goes on in other units of the library? Will material circulation – that is, lending services – cease or continue during the installation periods.

What best practices exist to guide the process of smooth and hitch free installation, whilst serving library patrons. It is important for these sensitive issues to be discussed and agreed upon during or after contract agreement.

3. **Weed your Library:** The term weeding refers to a library's effort to keep its collection new by removing books that are outdated, torn, and underutilized and thus, collecting dust and occupying shelf space instead of being used by patrons. It is an exercise that should be carried out in the library before RFID technology installation kick-starts. By doing so, time and resources that would have been invested on such non-useful materials is saved and utilised in another thing.
4. **Set up the RFID System:** During or after the library weeding, the vendor's project team configures the RFID technology across the points designated for them. The server, which is the backend database, is installed in any room within the circulation offices. The workstation is usually mounted at the circulation counter for use by circulation staff at the counter. The exit gate readers or sensors are attached to the exit cubicles or pass lanes. Where the reader devices have no inbuilt antenna to recognise and read tags independently, appropriate RFID antennas, as external devices, may be mounted at various corners of the library to enable data reception and communication between tags and readers. If agreements were made to include automatic self-check-in and check-out stands or kiosk, as well as book-drop stations outside the library building, the project team configures the same.

5. **Commence Tagging (pasting over each tag the library's security label):** After ensuring that all collections in the library are in good state, relevant and current, the next step is to start affixing RFID tags on library materials. This is an important aspect of every RFID project and is therefore undertaken with care. It can be tedious and time consuming depending on certain factors. One, is the library collections already managed electronically? Or is RFID the first technology to be adopted in the library? Two, how many persons will execute the tagging assignment? For example, in a case where a library's collection is already enabled on the Barcode technology, the experimented time for completing tagging and identifying each material is one minute. Apparently, RFID tagging is an assignment that is completed with some managerial discretion. In some cases, library management decides to conceal information concerning where tags are placed on library items. Such information can even be hidden from the entire staff of the library, and be reserved exclusively for designated technical staff members. The idea is to maintain safety of the tags because the removal of tag from an assigned material renders the material unreadable to the RFID reader. However, in other observable cases, the spot on which the tag is placed is not hidden from staff and patrons who may care to know. Whichever be the case, it is good to provide some protective covering to RFID tags by placing a library security sticker, label or logo over the RFID tag.
6. **Reader-scan, identify and programme each tagged material into RFID server to assign unique identity:** Each tagged material is thereafter scanned on the reader machine to describe and programme their data in the server and assign a unique identity to each

tagged material. This process can be completed along the time of tagging each material, or as a distinct exercise executed when the entire tagging assignment has been concluded.

7. **Mark tagged materials:** After tagging and programming each tagged material into the RFID server to assign unique identification to them, a specific seal or mark is made on tagged materials to distinguish them from untagged items. With this, library circulation services, particularly book borrowing and return activities, can continue during the tagging exercise and reach the entire library collection without omissions and mix-up that may arise from material circulation.
8. **Shelve and shelf-read all tagged materials:** Shelving and shelf-reading are crucial aspects of collection management in libraries. Whereas shelving is the act of returning used books to their appropriate shelves, shelf-reading ensures that books returned to the shelf are orderly arranged according to their call numbers. Hence, after tagging, assigning identity and marking tagged materials, they are thereafter shelved and shelf-read to take stock of the collection and obtain other necessary managerial information concerning the holdings of the library.
9. **Test-run the technology:** Testing the workability of the RFID installation is a necessary step that the vendor's project team must complete before handing the technology over to the library. It is a way of ensuring that all the components of the RFID are working as designed. Test-running can last for one week or more. During the period, library staff and patrons would be made to compulsorily utilise the technology. Staff should be able to use the handheld reader to shelve-read, search for books on shelf, and take inventory of

library collections. Staff can repeatedly test the sensors at the library exit lanes by passing through the lanes with books that are not checked-out. Circulation staff should confirm that deactivation of tags on borrowed books and the activation of same on returned books are one-click away commands on the RFID computer system. But where there is a self-check-in and check-out station provided within the circulation hall, patrons should be made to check-in and check-out books by themselves, while their ease and success in doing so is monitored and approved to be hitch-free. Again, where RFID book return boxes are installed, staff must confirm that they function very well. Moreover, staff must affirm that the RFID readers read tags and transmit to server instantaneously and accurately. So, before taking delivery of the RFID library management system, it is imperative for the librarian to ensure that the overall functioning of the RFID technology is tested and confirmed to be satisfactory in library security control, shelf management and circulation services administration.

10. **Get library staff trained satisfactorily to manage the RFID system:** Following the completion of testing and accepting the RFID library system is the need to train the appropriate library staff on how to use the RFID technology. The project team will educate and guide library staff on how to maximally deploy and operate the RFID library management technology.
11. **Use the RFID library technology:** As many competent hands emerge from the training of library staff members on the use of RFID technology, the library as an institution is thus required to take delivery of the RFID library management system from the vendor's project team and implement the technology in all areas designed for it.

12. **Sustain the initiative and harness its capabilities:** A good maintenance culture is paramount to a successful lasting use of the RFID technology in a typical library management. Components and accessories of the RFID technology should be monitored regularly and kept in good condition. It also advisable to have a knowledgeable and diligent ICT staff posted to the library to closely supervise and manage the RFID technology.

Challenges Facing the Implementation of RFID in Libraries

RFID library management systems have been adopted by many libraries to enhance their operations and services. However, like any technology, RFID library systems face key challenges in its implementation and maintenance in libraries. The major factor according to Santhosh and Pange (2013), is cost of implementing an RFID system which can be quite expensive, especially for libraries in third world countries with limited budget allocations. The upfront costs of RFID tags, readers, software, and staff training can be a significant financial burden. It was also recorded in their work that while RFID technology allows for efficient inventory management, maintaining accurate item locations on shelves can be a challenge. Items might be misplaced or not returned to their designated places, leading to discrepancies between the system's records and actual item locations.

Integrating the RFID system with the existing library management software and infrastructure, according to Boss (2014), can be highly complex and time-consuming. Ensuring seamless communication between the RFID components and the library's databases is crucial for efficient operation. He further pointed out that lack of trained staff to manage RFID systems also possess great challenge as they need to be acquainted with the new technology, understand the

RFID tags, and manage the RFID-enabled processes. Staff resistance or lack of adequate training can lead to difficulties in utilising the system effectively.

In the same vein, tag interoperability is also known to be one of the challenges. Molnar and Wagner (2016) recorded that there are various types of RFID tags available in the market, and not all of them are compatible with each other. Therefore, choosing the right tags and ensuring their interoperability can be challenging, especially when dealing with different suppliers or vendors. They also pointed out that inaccuracies in tag reading can occur due to tag misalignment, tag failure, or interference from other electronic device thereby leading to items not being properly checked in or out, causing disruptions in library operations.

Golding and Tennant (2018) reiterated that implementation of RFID in library is also faced with security and privacy concerns as RFID systems store sensitive information about library materials and patrons and if not properly secured, faces the risk of unauthorized access to this data and potentially compromising the privacy of library users. They equally posited that some patrons might attempt to remove or tamper with RFID tags to steal library materials. This is an often rare, but possible situation, a case where an RFID Tag is deliberately removed from a library material to aid its theft and thus breach the efficacy of the RFID system.

Environmental conditions, such as humidity, temperature, and electromagnetic interference also affect the performance and longevity of RFID tags and readers, coupled with the cost of system maintenance and upgrades in order to stay current (Cunningham, 2010). However, amidst all these challenges, the implementation and use of RFID in libraries offer great advantages that cut across appreciable security controls, retention of manpower requirement,

excellent shelf management, effective circulation of library materials, durable Tag life and appearance. Hence, the advantages of implementing RFID in libraries far outweighs the potential challenges and is therefore a project worth investing on.

Conclusion and Recommendations

RFID is of great importance in today's libraries. Whereas the advantages of the RFID technology in libraries cut across security, reliability, retention of manpower requirement, superb inventory control, and durable tag life and appearance; there is no contesting the fact that the technology also have its drawbacks. Hence, the obvious disadvantages of the RFID library management system include its acquisition and implementation cost, the vulnerability and possible removal of the RFID tags from library materials, making it impossible for such materials to send signals to the RFID reader and server respectively. Noting therefore that a library material without an RFID tag cannot be read or detected at exit gates, this paper recommends that libraries should:

1. Ensure that the spot where tags are placed on materials is concealed and all information about it kept secret. At least, it will be a way of safeguarding the tags and making it difficult for patrons to break the security.
2. Strengthen and continue the age-long practice of physical patrol by porters in reading halls.
3. Mount CCTV cameras in the reading halls to possibly inspect patrons' activities in the reading halls and possible detect attempts to remove tags from library materials.
4. Think along the incorporation of broader and comprehensive technologies such as the Internet of Things technology – a technology that flexibly embody several other

management technologies – to complement the often rare but possible drawbacks of RFID management system.

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