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IMPLEMENTATION OF UHF-RFID TECHNOLOGY IN AN ACADEMIC LIBRARY OF PAKISTAN; A CASE STUDY

Attya Shahid Ms
National University of Computer and Emerging Sciences, attyashahid@gmail.com

Naveed Sehar
University of Karachi, Pakistan, nsehar@uok.edu.pk

TOPIC: IMPLEMENTATION OF UHF-RFID TECHNOLOGY IN AN ACADEMIC LIBRARY

OF PAKISTAN; A CASE STUDY

Attya Shahid[1]

NUCES-FAST Library, Pakistan.

attya.shahid@nu.edu,pk

Naveed-e-Sehar[#2]

Department of LIS, UoK, Pakistan.

nsehar@uok.edu.pk

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Abstract

There are numerous libraries in Pakistan that cannot afford RFID technology because of the limited budget and resources and confronted book theft, low security, and delay services. This paper base an experiment that how libraries can adopt this technology effectively and productively with a lower budget and higher outcomes. The FAST-National University of Computer and Emerging Sciences Library Karachi campuses is the principle library in Pakistan which has adopted UHF-RFID technology with the integration of ILS insignia; SIP II compliance that jointly works with library integrated system and numerous activities can be made through this. An exploratory study conducted in the FAST-NU library to implement UHF-RFID technology in two stages; in the first phase issues and requirement identified and the second phase criteria developed and a committee reviewed its features then observation took out as prerequisites and implementation made. Results show that UHF RFID is out-performed in terms of the in-door frequency range, multiple-item detection, integration, and ease of use. The equipment placed outside the library at the ceiling downward direction at full frequency 2920 MHz which started reading at 1 feet distance. Further, Integration was done by an application as hardware was not SIP II manufactured with the goal that any operations can be controlled. All hindrances removed after test and retest; however, it is a tedious process of pasting tags on each book but. implementation of this technology save costs, improves client assistance, Increases work accuracy and inventory, and gives patrons a brisk borrowing process with privacy and independence. It reduces overcrowded library counters and maximum library staff availability at users service, in addition book drop option able to return books during off-hours. The main drawback of this technology is human well being is needs to be considered as ultraviolet radiation cause harm to human health. Additionally, lack of user awareness, damaging of tags on books might create a problem if not fixed inside the book appropriately.

Keyword: Ultra high frequency wireless technology, Integrated library system, SIP II compliance protocol., Passive tags, Artificial Intelligence, Internet of thing.

INTRODUCTION

significance of RFID technology is remarkably well-known in libraries. Numerous studies and development has been done on Gharat (2017) stated that "RFID is very interesting technology for indoor positioning because of its low operating cost and low power consumption", but still when it's come to its implementation in Pakistan cost matter most and no efficiency is provided without spending heaps of money; however, Ultra high Radio frequency identification (RFID) is one of today's most exciting and fastest growing technologies for theft detection in libraries (Radadiya et al., 2019) expressed that It improves the work process, work proficiency of the library staff, the satisfaction of readers, easy circulation and book location. UHF has less used in library arena, but a study conducted regarding the use of theft detection in Pakistanis libraries (Yousuf Ali, 2017) found that even so aware of the university's academic write off policy, majority academic administration made librarians paid for loss

material which is an unusual practice in Pakistan whereas according to Naseer Muhamad (2011), "losses up to 3% per annum can be written-off by the competent authority in a library having open access system while losses up to 2% can be written-off in a library having closed or partially closed access system" (p. 6). National University of Computer & Emerging Sciences - FAST Library is one of the state of art library in Karachi, Pakistan. It has 06 campuses in Pakistan including two in Karachi city, there are different timing of library operational services which vary from campus to campus and make it difficult to manage theft detection in libraries within limited resources because currently the library has around twenty thousand collections of books and out of it 60 percent of its assortment import books which need to be in a safe and secure environment, but availability of resources and accessibility of staff in differed timing is progressively complex. In two different campuses of Karachi, UHF-RFID implemented; city campus starts at 1:00 till 09:00 pm whereas Main campus has 08 :00 to 04: 00 pm timing. Library has the longest opening hours in weekend and due to the limited number of staff, work load and lack of funding, it always remain hurdles for it to implement RFID technology in library, whereas, when it became impossible for library to control theft detection by manpower so keeping in view of given limitations, UHF-RFID implemented with integration of Insignia ILS. This library is popular to serve its external clienteles including alumni and guests, exams are held in three break up in each semester and these are the peak hours for serving patrons and managing library users. During the terms users usually visits for short intervals but exams are the most busiest timing of the semester. Library staff are busy in routinely chores related to answering queries, updating library data and to reduce the work burden and increase work efficiency.

An OVERVIEW OF RFID TECHNOLOGY

previous studies described that implementation of RFID technology is not new and its has a deep impact on library operation and its services with accuracy; similarly, (S. Ching & Tai, 2009; Sumi & Kumar, n.d.) stated the RFID system is not new, this was established in the late 1990`s. At first it was center of attention for commercial use and was unproven in library arena. Numerous problem in library brief its importance in library operations. (Prantika & Mishra, 2016) described, its preliminary aim is to theft detection, fastest record updating, but numerous challenges are being faced libraries in Pakistan in term of security, safety and protection of these resources. Book theft is a serious issue, (Yousuf Ali, 2017) study revealed that serious objections received by auditors and academic universities, made librarians pay stolen library material. There is law for write-off material which seems not followed like (Naseer, 2011) paper aim is to provide guideline and support to brief the write off policy with detail procedure and methods including sample data for book loss for professionals. And due to expensive, having a limited knowledge RFID implementation remain hurdles for libraries in Pakistan, difficult to resolve a theft-issues in

libraries; however, (Dong-Ying Li et al., 2016) designed a UHF reader and management system established; results showed that the system could effectively complete the functions of automatic borrowing material, book location, and material counting. Further, many advancement has been made and many ideas are being proposed in it, like, (Pratt & Zhong, 2019) proposed thin RFID antenna can be inserted between shelves to read its credential, (Wang & Liu, 2017) with the use of IoT increase the efficiency of library material includes user identification, Inventorying, refreshing, searching and browsing and self check-in and check-out. Further, passive tags gives the cheapest solution to implement this technology, saves energy and give accurate information ,likewise, (Liang, 2018) review scientific Literature on IoT in library operation and reports its future trends and challenges and finding show that it has potential impact on libraries application.

UHF vs HF RFID

This is a general understanding with previous studies that UHF RFID has more potential than HF technology. Infact, both technology works at different frequencies, UHF outperforms in term of reading speed and longer range., (Sumi & Kumar, n.d.) assured that it can be adopted and utilized effectively in library as well. This ensure multiple item detection as well as faster responses. The emergence of wireless technology bring opportunities and its application can be used in more than one environment. Adopting UHF approach in library environment ensure high reading range, accuracy, multi item identification, reduce loss, and improves services ,like, self services; circulation, inventory, item searching. Moreover, based on the success in many libraries worldwide, FAST-NU library began to explore solutions with proper compatibility. Previously many HF-RFID solution used in different academic libraries of Pakistan, but faced lots of issues like limited reading range, low-frequency and high cost of it. Therefore, libraries are reluctant to adopt RFID technology when the progress rate is low and cost is high, this could becomes a new sustainable and affordable solution to all over libraries in Pakistan.

RESEARCH OBJECTIVE

To find out performance of UHF- RFID in library environment.

To find out the high - frequency in door reading equipment.

to find out integration with ILS integrated system.

to evaluate its security, privacy and safety

to find out its usability

To find out the low-cost UHF RFID.

METHODOLOGY

an experiment conducted in FAST-NU library to implement UHF-RFID technology. A study was conducted in two phases; in first phase problem and requirement identified and second phase a criteria developed and equipment evaluated and observation took out as per requirements and implementation made.

RESEARCH TEAM

The team formed including technologist with responsibilities of identifying UHF-RFID base equipment a committee reviewed the specification of equipment; work accuracy and budget limit was endorsed around RS 1.5 million. In this regard many vendors visited and performed a demoed under the supervision of library panel many things were observed including metal, body heat and water challenge with regard to this technology. Different tags were tested for better performance and it was found out that selected products do not operate in SIP II compliance which became significant reason ,at first, it was reluctant to adopt this technology then again a reasonable arrangements proposed because within budget limit it was not an easy choice to drop it. A solution was proposed to control this deficiency with software application and an application developed hired and work was done.

SELECTION OF UHF RFID EQUIPMENT

There are several rationales behind selecting the UHF RFID equipments
Numerous RFID UHF vs HF assessed and visited during the selection procedure including the IFLA meeting 2018 where some Taiwan, china based systems were part of the show and it has been recognized that the UHF will give the most ideal outcomes in term of accuracy and low-cost. Also it is a well-established reality that metal and water are the greatest challenges for this technology so metal non-obstruction chips were utilized. Moreover, Passive II tags were selected to save energy and accuracy with lock and unlock mode of data. The tags were accessible in various sizes and SIP II can be constrained by an application.

PRODUCT DESCRIPTION

A. UHF-RFID Reader

High-performance, sensitivity, and echo cancellation, up to 1200 tags/sec reading with Wi-Fi, Bluetooth connectivity with 2-port mono-static antenna selected which runs on Windows and Linux plus 512 MB Flash/256 MB RAM.

B. RFID Antenna

The bi-static operation & mono-static antennas picked. Large area coverage in nearly at a temperature of 40C which is usual temperature of the city and since it need to be placed outside at gate so antenna should be compatible with temperature otherwise performance may effect and could damage the equipment.

C. RFID Handled

Model Zebra MC3330R with interactive Sensor selected, Ability to push to talk, 10.5 cm(4"), has USB ports (2.0) with Bluetooth, Wi-Fi, Micro SD-Slot (max. 32GB), and 4 GB RAM with internal 32 GB memory, Android (7.1) software can be updates including battery 5100mAh, hand-strap.

D. RFID TAGs

UHF tags have long reading range and have fewer issues around metal and water and internal body-temperature and Passive UHF tags are easier and cheaper to manufacture than LF and HF tags. However; all libraries in Pakistan so far used HF tags which results low reading range and excessive number of issues, yet UHF has evolved quickly and now is being adopted widely for items identification. Libraries are now more considering UHF tags including other cooperate industries. Given charts show compatibility in use of tags and there is a possibility of customizations and sizes. Given the subtleties of UHF tags for item-level tracking, it is entirely clear that UHF RFID is the right choice for libraries. So as to investigate UHF tags for implementation many were tested; however, question remain should this resolve theft detection accuracy in libraries.

impinge base tags EPC class 1 Gen 2 is selected for implementation because of its high resistance of metal, water and body heat, compatible, price was slightly higher, and its data can be customize in lock and unlock mode with read and write option. Plus its operating range is from 902-928MHz. ETSI: 865-868 MHz ASIA: 950-956 MHz.

	Table 1: Compatible RFID Tags		
Model Number	PID-ROBO	Lt-01	Laxcen-C70
Relative Cost	$0.5 - .08	$0.08-0.50	$0.5
Frequency Range	902-928MHz	860-960 MHz	860-960 MHz; Global
Power Supply mode	Passive	Passive	Passive

Tag Thickness	92.5* 26.5 mm	flexible sizes	flexible sizes
Chip type	Customize	Customize	Customize
Common Applications	Library labels and others	Library books	Library materials
Tag Memory	128 bits	128 bits	128 Bits

PROCESS OF DEVELOPING STAGES:

A. Phase 1

- In view of local circumstances and library requirements accuracy, naturalistic environment, multiple item handling and efficiency of the system reviewed.

- Previous studies, experiences, and shared ideas, and scientific studies consulted to gather the central point which is accuracy, cost, performance, system integration, and easy use.

- Patrons survey conducted and it reveals that user-friendliness, convenience, and responsiveness and efficiency should high priority choice. Comments from library staff to make sure technical and operational needs.

- Product information from various vendors on different aspects of the frameworks was gathered.

- observations of the running system are also important to references.

B. Phase 2

a criteria developed in order to review its features

1..*Performance:* Physical environment and machine condition checks by pilot tests with different various sorts of equipment in order to distinguish multiple item response time, high reading range, self-check and accurate and quick retrieving.

2. *Security, privacy and safety:* Metal Interference, Body temperature, Water deterrent, tags safety and Human wellbeing were the greatest challenges; retesting made to expel all the obstructions that were considered as an impediment aside from human health.

3.*Cost*: machine, labels, Installation, and interoperability costs reviewed and tested on the selection of equipment, as UHF - RFID is insignificantly modest.

4. System integration: an application developed for Integration with the library management system, insignia. So as to send and receive data at SIP II protocol.

5. Usability: it was underscored that system framework, application use, and maintenance suppose to be friendly, easy and compatible with other application.

PERFORMANCE CRITERIA AND OBSERVATION

Table 2:UHF-RFID Features Observation

Criteria	Observation	Remarks
Performance		
• High-reading range • Multiple item detection and Accurate and quick retrieving	**Frequency Range with distance** | Frequency	Distance | |---|---| | 1000 dBm | 7 x1 feet | | 1500 MHz | 4 x 3 feet | | 2000 MHz | 5x 3 feet | | 2500 MHz | 4 x 2 feet | | 2920 MHz | 1 x 1 feet | Maximum 60 books per seconds will be read and minimum is 1.	It is based on local network environment, physical condition and machine environment; compatibility checks by pilot tests with various different types of equipment and hardware and selected with 2920 high frequency range with reading time 60 books per second.
Security		
• Metal Interference • Body disturbance • Water obstruction • Tag safety and Human health	High-technical metal detection tags used and to some extent body temperature and water resist. It customize with application so that only RFID books tags will read and passive tags will save more energy. Further, retesting made to oust all the hindrances that were considered as an obstruction beside human wellbeing.	general testing was done, problems featured and retesting made to remove all the impediments that were considered as a hindrance.
Cost		
UHF-RFID Equipment Installation & integration cost.	Expenditure | Items	QTY	Rate | |---|---|---| | Fixed Reader | 1 | Rs. 315,900.00/= | | RFID Anteena for indoor use | 1 | 80,000/= | | Zebra Handheld | 1 | 580,000/= | | RFID UHF Tags | 1 | Rs.28/= | | Alarm Indicator | 1 | Rs. 17,550 |	various products with costs reviewed and tested as UHF - RFID is profoundly modest as opposed to different innovations. Given charts gives summary of expenditure.
System Integration		
	Integration with SIP II compliance & ILS system	Integration was done by an application as hardware were not SIP II manufactured
Usability		
• User-friendly • Easy maintenance • System response time • Customizability	Users will be able to operate its functions and get easily update by server. It can be easily install and restored. Availability of around a clock network update its data easily and it can be further customize as per need in future -like- more than one report can be designed.	considering all things, it was underscored that system framework, application use, and maintenance suppose to be appropriate

IMPLEMENTATION

It remained difficult to implement such technology in Pakistan due to limited number of budget and resources; however some state of art libraries have implemented HF technology, but faced numerous issues like low-response, limited range and high expense Faruqi and Tyab (2008) argue that "The tags using this principle are generally passive and operate at ranges less than 3m in frequency bands of LF and HF" whereas UHF is the sustainable solution and has a huge success in corporate sector so implementation in libraries would be good solution. In order to implement the server with Linux created with apache and PHP using ubuntu operating system and installed the desktop application for operations. RFID tags placed on books and Book ID against the tag id saved. It inserted in the application and retrieved data as locked record so that it maintain accuracy of data, minimum life of tags is a decade and can be prolong by reusing it in case of item write off.

Initially, passive tags was pasted on 10,000 items. This task was divided into further section and at first library new arrival, reference books pasted, after most circulated items and most used subjects complete Computer science disciplined covered. The antenna, reader and alarm indicator placed outside the library at ceiling downward direction within a acrylic box and at full frequency used for best outcome, moreover, at each feet distance frequency reading recorded to get the best results at the distance of 1 feet. CCtv camera was installed to detect abnormal behavior and monitor whole objects at gate. The product total cost was Rs1.5 million which is comparatively low as compare to HF.It noticed that without the match of SIP2 compliance no interferences can be done so an application was created to control the interoperability between library integrated system and UHF-RFID and after execution, it was tested in terms of convenience, ease of daily maintenance, customizability and system response time. moreover, it proved that additionally application can be customizes as per operation and work environment. Installation on cloud server could give best outcomes. Library books with tags were taken out from the library and observed that 60 books can be read in a seconds so that chances of false alarm and no alarm were negative.

For human safety purposes, safety standards could be required while emitting electromagnetic waves. UHF is two-third cheap of the price of HF and it was found out that there are no huge differences in different brand prices in UHF equipment. there is hardly a few price difference in Taiwan and European base products. The downward trend of the UHF have been an advantage for choosing this technology.

RECOMMENDATION

time to time, libraries develop with new innovation to serve its patrons adequately. Libraries are consistently eager to try different things with new innovations to improve services. Clearly, innovation always gets a new phase to clients' in terms of quality services and effective activity. This UHF-RFID has exceeded results so libraries can defeat the insufficiency of theft identification and can save, organized, and deliver effective services within low-financial plan, and with the assistance of additional sensors shelve management can be done adequately. Further, the framework ought to secure protection by guaranteeing that they are just perused RFID labels and have well-established protection standards. Besides only authorized personnel should have access to the RFID framework application and server. In addition, No personal information should be stored on the RFID tags and prior to execution UHF RFID plan, a specialist committee must screen naturalistic condition, item correlation, and distance range with frequency should be covered. It is significant for the library network to check the accessibility of SIP II compliance. SIP II could be controlled by programming applications. Likewise, it is particularly critical for the library network to survey successful, auditable RFID frameworks. It must lead to an extensive innovation evaluation of RFID to get a viable framework with a good situation. Indeed, advancement in it can give much more room for new and innovative initiatives; smart shelves management sustainable system for developing countries, plus cloud base server will be a good alternative for reinforcement and maintenance and accessibility of use around a clock. Moreover, human well being is need to be consider as ultra violet radiation cause damage on human health and an experiment base study can highlight ultra violet rays impact on human health.

RESULTS

It found that it out-performed in terms of Frequency, multiple-item detection, and ease of use. Provided that conclude that there is a sufficient room for libraries to adopt this technology and can face the possible challenge of theft and high-cost. UHF RFID technology tested in term of performance, low-cost, high in door frequency range, integration with insignia, usability, security, privacy and safety. This UHF RFID equipment has high performance and libraries could defeat the insufficiency of theft detection and save, organized, and deliver effective services for its patrons. The indoor frequency range is higher above HF which libraries normally implemented whereas UHF RFID reads 60 books per second as per tested observation so that chances of theft is negative. Compatibility of equipments, environment and the machine framework checked by pilot test before implementation and make sure that it should have well-established protection standards. There is variety of frequency range which tested in this criteria with a distance of 7 feet item detected within frequency range 1000 dBm whereas as soon as frequency increase

the distance became shorter and reading of RFID label became more valid and authentic, and the antenna, reader and alarm indicator placed outside the library at ceiling downward direction at full frequency which is 2920 MHz which started read at 1 feet distance. Further, Integration was done by an application as hardware were not SIP II manufactured which jointly work with library integrated system and many operation can be made through this. All hindrance removed after test and retest; however, it is a time consuming process of pasting tags on each book and transferring barcode to this technology but. implementation of this technology save costs, improves customer service, Increase work efficiency and material handling, and inventory accuracy and gives patrons quick borrowing process with privacy and independence. It reduces overcrowded library counters and maximum library staff availability plus book drop option able to return books during off hours. The main drawback of this technology is human well being is need to be consider as ultra violet radiation cause damage on human health. Moreover, lack of user awareness, damaging of tags on books might create a problem if not fixed inside the book properly.

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