DEVELOPMENT OF RADIO FREQUENCY IDENTIFICATION BASED LIBRARY MANAGEMENT AND ANTI-THEFT SYSTEM: A CASE OF EAST AFRICAN COMMUNITY REGION

Deo Irankunda

A Project Report Submitted in Partial Fulfillment of the Requirements of the Award of the Degree of Master of Science in Embedded and Mobile Systems of the Nelson Mandela African Institution of Science and Technology

Arusha, Tanzania

October, 2021

ABSTRACT

Radio Frequency Identification Systems are becoming very useful and helpful in our daily life due to their advantages such as reduction of human error, theft prevention, time-consuming reduction, the auto-identification of targeted objects and data collection, find easily misplaced items as well as automating the processes business. Radio Frequency Identification systems have been applied in different areas including in library to manage items and library operations. Different approaches have been adopted to increase the efficiency of library management system in the East African region unfortunately, some challenges including theft of library item, pages removal, non-customer satisfaction, high cost of used system are persisting. To address the challenges an RFID system has been developed for East African Community Library. It used Ultra High Frequency (UHF) RFID readers and tags capable to send and receive data at a read range of 6m. The aim of this system is to speed up all library transactions, improve customer's satisfaction and keep a track of all library items. It enabled also librarians to have videos records of all library operations which were used to identify page removing actors and other unwanted behavior. The developed system will facilitate users borrowing and returning library items with the help of RFID-enabled modules without more human intervention and issue an alert if a non-issued item is detected when user cross the library entrance or exit. The Closed-Circuit Television (CCTV) camera and time-stamped access of library books provided with this developed system, will help to have video records of all library operations and facilitate to detect the actioner of the pages removal.

DECLARATION

I, Deo Irankunda, declare that this project report is my work, submitted in Partial Fulfillment of the Requirements of the Award of the Degree of Master of Science in Embedded and Mobile Systems in the Specialty of Embedded Systems. It has neither been submitted nor concurrently submitted for degree award in any other institution.

Deo Irankunda

Name and Signature of Candidate

15-11-2021

Date

The above declaration is confirmed by

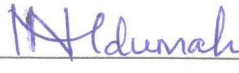
Dr. Mussa Ally Dida

Name and Signature of Supervisor 1

15-11-2021

Date

Dr. Neema Mduma



Name and Signature of Supervisor 2

15-11-2021

Date

COPYRIGHT

CERTIFICATION

I, undersigned certify that I have read and hereby recommend for acceptance by the Nelson Mandela African Institution of Science and Technology, a Titled project "Develop and Implementation of RFID based Library Management and Anti-Theft System: A case of EAC" in Partial Fulfillment of the requirements of the award of the degree of "Master of Science in Embedded and Mobile Systems in the Specialty of Embedded Systems".

Dr. Mussa Ally Dida

Name and Signature of Supervisor 1

15-11-2021.

Date

Dr. Neema Mduma

Name and Signature of Supervisor 2

15-11-2021

Date

ACKNOWLEDGMENT

I, first render my deepest thanks to God for being a refuge, support, a help that never fails in distress. I cannot keep quiet to thank the Almighty for his infinite love, kindness, and protection throughout our student careers, keeping me alive and granting me the opportunity, strength, and ability to accomplish this work.

My special gratitude to the Centre of Excellence for ICT in EA (CENIT@EA) for being my financial support and funder during this master's studies.

I express my distinguished appreciation to my supervisors Dr. Mussa Ally Dida and Dr. Neema Mduma for their time, support and guidance during this research study. They have been blessed people and unforgeable in my life. Their motivation, knowledge, and perseverance strengthened me and induced me to work hard. I also recognize the great support from Dr. Sinde Ramadhani, his insightful comments and technical advice served as a source of strength that enabled me to execute this work with a loved heart.

I am extremely thankful to Eng. Daniel Murenzi the Principal ICT officer at the EAC secretariat, my host company supervisor for his motivation, encouragement and supports which makes this work successful.

I also address my thanks to Mr. Costantine Mashauri, EAC Senior library officer for sincere vision, contribution and motivation which inspired me to accomplish this study. Finally, I'd like to express my profound acknowledgment to Reverend Joram Ngenzirabona for his unconditional love, moral, and material supports together with prayers. My classmates and colleagues from NM-AIST and others whose names are not listed who participated the accomplishment of this work may find my thankful in the book.

May the peace of God fill you up.

DEDICATION

I devote this work to my esteemed parents Mr. Pascal Ntewahorirwa and Mme Liberath Nimbona for their dedicated time and encouragement that strengthened me during the entire academic journey.

TABLE OF CONTENTS

LIST OF TABLES

LIST OF FIGURES

LIST OF APPENDICES

LIST OF ABBREVIATIONS AND SYMBOLS

CCTV	Closed Circuit Television
CD	Compact Disk
CENIT@EA	Centre of Excellence for ICT in East Africa
CSS	Cascading Style Sheets
DC	Direct Current.
DVD	Digital Versatile Disk
DVI	Digital Visual Interface
DVR	Digital Video Recorder
EAC	East African Community
EM	Electro-Mechanical
GNDEC	Guru Nanak Dev Engineering College
GUI	Graphical User Interface (GUI)
HDD	Hard Disk
HDMI	High-Definition Multimedia Interface
HTML	Hyper Text Markup Language
HUA	Hope Africa University
ICT	Information and Communication Technology
IDE	Integrated Development Editor
ILS	Integrated Library System
IRC	Information Resource Centre
ISBN	International Standards of Book Number
ISO	International Organization for Standardization
LF	Low Frequency

LMS	Library Management System
MLMS	Manual Library Management System
MVC	Model View Controller
NVR	Network Video Recorder
OPAC	Online Public Access
PHP	Hypertext Pre-Processor
RDBMS	Relational Database Management System
RF	Radio Frequency
RFID	Radio Frequency Identification
RLMATS	RFID based Library Management and Anti- Theft System.
SDLC	System Development Life Cycle
SQL	Structure Query Language.
TCP/IP	Transmission Control Protocol / Internet Protocol
UHF	Ultra High Frequency
VGA	Video Graphic Array

CHAPTER ONE

INTRODUCTION

1.1 Background of the Study

A library is a curated collection of sources of information and similar resources, selected by experts and made accessible to a defined community for borrowing, reading, often a quiet environment for conductive study (Dhanalakshmi & Mamatha, 2009). It is a place where people can get information in a different format found in various materials that a library holds such as books, newspapers, manuscripts, films, maps, documents, CDs, cassettes, prints, e-books, audiobooks. A library is an important part of the academic sector as well as professional sectors and serves to support the school's curriculum and research (Isebe, 2014). A library can appear in different types such as academic, private and public. Library size is defined depending on the number of items it contains that can be counted from hundreds up to millions (Tosin, 2015). Often, having a big number of items in the library may bring a lot of challenges when it comes to the purpose of management and achievement of fixed goals and objectives of the library. According to Masood (2019), a library to accomplish its objectives and goals need efficiency in its operations, which lies in how the books are arranged and how easily users can get books of their choice, issuing and return borrowed items (Padmaj *et al*., 2019).

Library Management System has been defined differently by various authors (Koneru, 2004) described library management as the act of keeping an eye on library department functions and maintain all records of the library in such a way a library stays in an operatively and keeps constant track of all library items in store. According to Smith *et al.* (2007) and Richard (2012), library management is a developed system for handling basic functions of a library, providing a complete administration solution for a library's technical function and services to the defined community. It includes areas such as circulation of books or reviewing, classification of materials, catalog management, patron management, online access, search facility, report, subscription (Satrusallya & Wunnava, 2019).

Furthermore, the presence of Information and Communication Technology (ICT) has become a concern of many companies and institutions around the world and influences them to be transformed from a tradition to a computerized approach. Referring to the work of researchers it shows that manual system comprises a lot of limitations than the computerized system. Some

of these limitations are time-consuming, human errors, hard book location, staff stress, difficulty of auto report generation (Vijayagowri & Kousalya, 2016). According to Singh (2014), a library assistant at Guru Nanak Dev Engineering College, Ludhiana (GNDEC), Information and Communication technology has brought a remarked change in the different prospectus of human endeavor (Singh, 2014).

As libraries remain the primary source of information for thousand people, their management have been taken as a key feature of many organizations including EAC which need to be improved and reinforced (Bitter-Rijpkema *et al.*, 2011; Warwick *et al.*, 2008). On handling library management, several technologies such as barcoding, RFID, software-based, can be used in the prospectus to automate activities in general. Many institutions have also adopted the use of software-based library management which enabled them to reduce time-consuming, keep track of library materials, and auto-generate the reports (Tripathi, 2012). Despite works that have been done, libraries around the world are still experiencing several challenges such as theft, pages removal, high cost. These challenges persist followed by addition of improvised budget for item replacement. Therefore, this study aimed to develop RFID based Library Management and Anti-Theft System to the EAC region to provide features of maximization of time, prevent theft, keep track of library items, and have video records of all library operations. The system automates the book handling process including checkout, check-in, shelf management, item borrowing, and returning without requiring more human interaction.

1.2 Statement of the Problem

While libraries are growing in size, the problem associated with maintenance and security is also increasing (Kadari & Prasad, 2011). Nowadays, manual library managements systems are more vulnerable to many disadvantages which induced in most cases to be replaced by automated systems (Singh & Sharma, 2015). Furthermore, libraries around the world are facing major problems such as theft of library items, page removing and time-consuming. Theft is mostly done at a higher level and brings a negative impact by affecting library finance, archives of different types as well as academic objectives. According to Weiss (1981), pressure for academic success is a factor that increase book theft among students (Isebe, 2014). This problem started in past years and it's still ongoing in different libraries. In 2014, Simon Thomsen via his audit done in August at the State Library of New South found that 12 rare coins, valued at nearly $ 1 000 000, including an 1813 'Holey Dollar' worth around $ 500 000 had been stolen. Recently in 2018, an audit done by Pall Mall Art Advisors at Carnegie library

discovered that over 300 items valued at about $ 8 000 000 had been stolen. Different technologies such as barcode, software-based library management have been used for a systematic and organizing way of keeping records and accomplishing many transactions. However, due to several limitations of these technologies, some of the problems remain unsolved. Furthermore, RFID as the new generation technology with several advantages in its applications has been used as a solution in library management. This technology demonstrates the ability to read the hidden item and alert in real time. However, the system is not compatible when the RFID transponder will be removed (Kaur *et al.,* 2011). The addition of a CCTV camera system has been considered in this study. The system uses radio waves to identify the tagged object and it does not require line of sight or physical contact as barcode technology, able to read multiple tags per second within a read range of 6 meters. Finally, on implementing this system, the passive tags were embedded on library items and user cards. The Radio Frequency Identification readers will be able to read all tags properly and put at the end the theft problem observed in many libraries.

1.3 Rationale of the Study

The presence of Information and Communication Technology (ICT) has become a concern of many companies and institutions including libraries around the world and influences them to be transformed from a tradition to a computerized approach. Referring to the work of researchers it shows that manual system comprises a lot of limitations than the computerized system. Some of these limitations are time-consuming, human errors, hard book location, staff stress, difficulty of auto report generation (Vijayagowri & Kousalya, 2016). As libraries remain the primary source of information for thousand people, their management have been taken as a key feature of many organizations including EAC which need to be improved and reinforced (Bitter-Rijpkema *et al.,* 2011; Warwick *et al.,* 2008). Despite works that have been done, libraries around the world are still experiencing several challenges such as theft, pages removal, high cost. These challenges persist followed by addition of improvised budget for item replacement. Therefore, this study aimed to develop RFID based Library Management and Anti-Theft System to the EAC region to provide features of maximization of time, prevent theft, keep track of library items, and have video records of all library operations.

1.4 Objectives

1.4.1 General Objectives

The main objective of this project is to develop library management and anti-theft system based on RFID technology.

1.4.2 Specific Objectives

The specific objectives are the following:

(i) To analyze the requirements for developing the library management and anti-theft system.

(ii) To design and develop the RFID based system for library management and an anti-theft system.

(iii) To validate the developed system.

1.5 Research Questions

(i) Which techniques can system be used to develop the library management?

(ii) How to manage the library?

1.6 Significance of the Project

For adequate library management, it is important to understand how a library is playing part in the academic domain as well as in other domains. This study helps institutions to automate the library's activities, provides a reduction of staff stress, timesaving, keeps track of available library items, users, and borrowed items. The most significant surveillance is attributable to the fact that CCTV camera is much faster in recording with good resolution. Unlike Electro-Mechanical (EM) systems which have been used in libraries for decades, RFID used in this study move beyond security to a tracking system that combine security with more efficient tracking materials throughout the library, including easier and faster charge and discharge, inventorying, and materials handling. The study will also help in giving insight to academicians and others professionals across regions, specifically the EAC countries to consider different factors that affect library management.

1.7 Delineation of the Study

This study aimed to develop RFID based Library Management and Anti-Theft System to the EAC region to provide features of maximization of time, prevent theft, keep track of library items, and have video records of all library operations. The system automated the book handling process including checkout, check-in, shelf management, item borrowing, and returning without requiring more human interaction. In human life problems and challenges can appear and sometimes produce the disturbances. It has been the same during development this study where the following limitations appeared and brought various barriers: COVID-19 has been barrier for crossing countries borders in data collection phase, some devices were not found in local market markets which took long time to be shipped from out of the country.

CHAPTER TWO

LITERATURE REVIEW

2.1 Manual Library Management System

Traditional libraries have the same models of sharing information to a defined community with automated libraries. They comprise a collection of diverse materials of different formats such as books, periodicals, magazines, manuscripts, researcher's papers. A manual library management system is the action of keeping an eye on library department functions and maintain all records of the library in such a way that it operates in a manner and keeps constant track of all library items in-store whose all processes are done manually (Green, 2007). The manual system requires books and pens for registration, borrowing, and returning processes. with the maximum human intervention.

2.1.1 Disadvantages of Manual Library Management System

According to Vijayagowri and Kousalya (2016), manual method is very difficult for records verification of a week and above. It is vulnerable to human error, very slow to operate, large storage amount of data, and is very exposed to loss (Burke, 2007). This type of management left behind the information highway and induce non-user satisfaction. It deals with printed materials while users want to supplement the printed information with more dynamic resources and demands for digital information tend to increase daily (Bamgbade *et al.*, 2015).

The manual method is less efficient where searches take long-time and require to move from one index to another while in the automatic methods searches are very simple and users can conduct few clicks in the same location. The traditional library management puts limits on the future in the context of limiting users to have access to a growing body of work while any quality of the automated system by contrast grant remote and on-site access to most resources (Waller, 2013).

Figure 1: Disadvantages of a Manual Library Management System

2.2 Computerized Library Management

An Integrated Library System (ILS) is an enterprise resource planning system for a library which tracks items owned, orders made, bills paid and information of library patrons. The presence of computers and software changes manuals tasks to be completed automatic way. It differs from the traditional library by the fact that files are easily accessible and all records are stored electronically on the server.

2.2.1 Definition of Terms

(i) **Catalog management:** Catalogs of libraries are kinds of registers or a collection of records of all knowledge resources founding into a library or the group of libraries located in different areas. It deals with keeping track digitally of what is available in the collection. It produces and creates standards descriptions of the library's documents. Furthermore, a catalog compared to the book index helps to find easily required information. Simply users take a look at the index without going through all the book pages and are automatically directed to the page containing searched information.

(ii) **Cataloging:** it is the process of creating metadata that represents the information resources, such a books, articles, newspapers, sound recordings, documents, and maps (Cabonero & Dolendo, 2013). The above process requires the respect of defined rules for cataloging such as:

- A.A Code or Joint Code (UK and USA rules together)

- American Library Association
- The Vatican Code (for printed books)
- British Museum Code
- Classified Catalog Code defined by Dr. S.R. Ranganathan.

The use of cataloging in a library has the fundamental purposes of managing the library works efficiently, locating and retrieving the required knowledge resources easily, saving efforts and time of the staff and user, and finally assisting users with an alternative knowledge resource.

(iii) **Patron management:** This feature deals with the user's information tracking and records. This option allows librarians to add and approve users, edit user data, providing user access, remove users and miscellaneous which deals with user's data exportation in excel sheet and developer API for user management.

(iv) **Self-check-in/check-out:** Allowing library patron to check their items in and out of the library.

(v) **Circulation management:** This feature enables tracking the movement of library items by knowing who took the library items, at what time items have been returned, issued and reserved.

2.2.2 Features of Computerized Library System

A computerized library manangement system has been intended to automate, oversee and care general handling of even enumous scale libraries. This productive is fits for overseeing book issues, returns, users management, reports generation, Online Public Acess (OPAC), calculating fine (Ng *et al.*, 2020). In a general manner, a computerized library management can have not an exhaustive list of features, depending on the programmer's features which may be more compared to these listed in the Fig. 2.

Figure 2: Features of Computerized Library Management

2.2.3 Comparison of a Manual and Computerized System

Table 1: Comparison of Manual and Computerized System

Aspects	Manual System	Computerized System
Error	Vulnerable to human error	Free error
Time	Time-consumming	Time saving
Update	Left behind on the information highway	Provides information update
Accessibility	Data are hardly accessible for more than one user at the same instant	The data is momentarily and can be made available to various users located differently instantly.
Cost	This system requires papers and pens which are very cheap Howerver, it is very expensive when it comes at side of staff	Computers and software are which make this system to be expensive compare to manual system. It comes very recommended and acting important on human resourses management. This system becomes a cost saving.
Backup	Not possible	All transactions can be saved and backuped easily. It becomes a key features of information security.
Transactions – Records	Manual methods are used to records all transactions	The use of computer becomes very important in transactions of records.
Retrieval of data	It becomes diffuclt and time-consumming to retrieve data as all books have to go through	Retrieval of data is very easier as the records are kept in soft copy and be stored in a database.
Efficiency	Difficulty to find efficiency	Data can be retrieved quickly by respecting the given instructions with computerized system, inventory control, collection, use of resources and time becomes very appreciable
Speed	Slow	Very faster
Report generation	Taking a long time to go out and be subject to a high computation error	It can be produced in a short time accurately, complete, interesting for presentation and good for printing.

2.3 Barcode Technology

Barcoding technology is a technique to represent data in a visual and machine-readable form. This method involves a combination of series of parallel white and black lines readable with an optical barcode scanner (Hassan & Ruchi, 2018). It comprises two main parts whose reader adds a barcode tag to be attached to the object. To read, a barcode needs to be scanned by a laser and then interpreted. A barcode tag is devised in three parts such quiet zone at the beginning, barcode symbols in the middle, and quiet zone at the end as shown in Fig. 3. This technology has been used due to accuracy, speed, and reliability. The barcodes exist in two types:

(i) **One dimensional (1D)** is used to symbolize data by varying the width and spacing of parallel lines. This involves some of the most traditional and well-recognized barcodes types such as UPC and EAN codes. The length of a one-dimensional barcode is direct tied to how much information it holds. Often, one-dimensional code has a limited number of characters that cannot be exceeded (8-15). One- dimensional are mostly used to execute enterprises functions for the purpose of saving time and making inventory workflow more effective.

(ii) **Two- dimensional (2D),** similar to 1D but different in information storage capacity, symbolize data in two-dimensional symbols and shapes. They involve Q-R and PDF417, the new types of barcodes. Two-dimensional codes are designed to keep data intact and scannable even after being ripped, scratched, or damaged.

However, barcoding technology is considered as old technology with more limitations which induced it to be not widely used in libraries (Chanda, 2020; Peta, 2000).

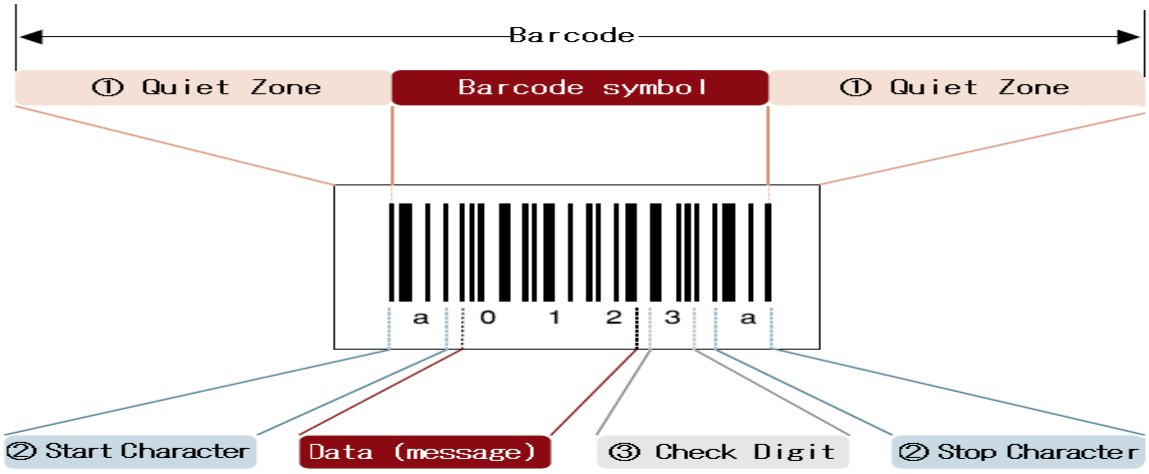


Figure 3: Barcode Components

2.4 Radio Frequency Identification in the Library

A Radio Frequency Identification is a computing technique based on the use of radio waves for transferring and receiving data between a reader and movable item for the purpose of identification, categorization and tracking wirelessly (Grover & Ahuja, 2010). It facilitates library transactions with help of RFID modules. It directly provides the targeted object and user information to the library management system without human (manual) typing. This method is fast, secure, and provides a unique identification and backend integration. Radio Frequency Identification system comprises of three main components which interact with a computer system:

- RFID readers
- RFID tags/labels
- Antenna
- Database

A Radio Frequency Identification reader and transponders are designed with a microchip inside to deals with signal processing and antenna for sending and receiving data via radio waves. Transponders exist in two types which can either be actives with a battery inside or passives with non-battery inside (Nisha, 2018). Passives transponders are powered by the radios waves from the RIFD reader (Vijayagowri & Kousalya, 2016). The use of RFID in library provides the following features:

- Remove manual bookkeeping of records
- Trace library 'items and members when moved
- Improve utilization of resources like manpower and infrastructure
- Minimize time- consuming and avoiding more human interaction
- Provide a read range of more than two meters
- Provide the long-lasting labels
- Facilitate fast searching of books

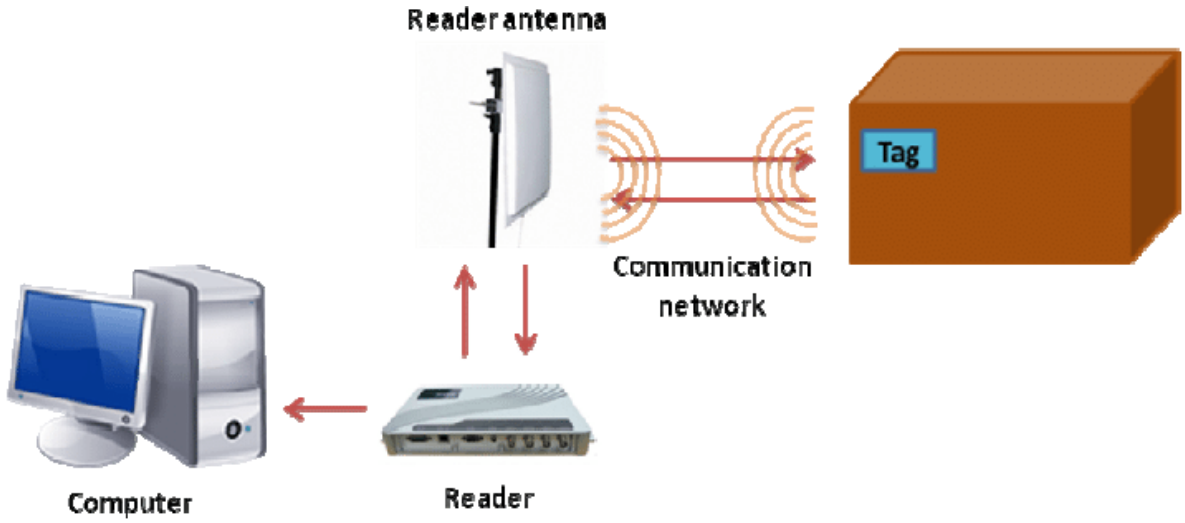


Figure 4: Radio Frequency Identification System Components

2.5 Advantages of RFID Compared to Barcode Technology

Table 2: Comparison of RFID and Barcode

RFID	Barcode
Have a read range of long-distance in terms of meters	Much smaller and lighter read range distance in terms of centimeters
RFID tags do not require a physical sight with the reader	Require physical contact with the scanner to scan a barcode
Do not require human interaction	Require human interaction
RFID reader read multiples tags at the same time	Read a single card
RFID tags are read/write devices	Not programmable

RFID knew high levels of security: encryption of data, protection of the password.	Today barcodes are found on almost every item and there are no privacy issues involved with its use
RFID tags have large data storage capabilities	Today barcodes are found on almost on various materials in which they are placed
Once these are set up, it can be run with minimal	Require more human interaction participation
RFID tags are protected by plastic cover which make them to be reusable and rugged	In many cases barcode accuracy has been said to be the same or even better than RFID tags
Good readability	Barcode readability can be affected by moisture, dirty, absorption, packaging.

2.6 Ultra-High Frequency Radio Frequency Identification Technology

Radio Frequency Identification technology works in the different bands of frequencies and each group has its typical uses because of its inherent advantages (Saleem, 2012). Low-Frequency RFID using a band of frequency (125-134 kHz) which induces it to have a short-read range approximatively in terms of centimeters between reader and transponder. Furthermore, HF RFID is commonly operating in a band of frequency of 3 to 30 MHz with the reading range of 10 cm to one meter while Ultra-High Frequency RFID tags have the largest read range and big speed. The passive RFID tags type ultra-high frequency have the capacity of being read at a short distance compare to active RFID tags of the same band of frequencies (Gilbert-Rolfe, 2017). Passive can be read at 12 meters while actives tags can even be read at more than one hundred meters (OECD, 2008).

Figure 5: Radio Frequency Identification Integrative Long-range UHF Card Reader

Figure 6: Desktop Ultra-High Frequency Radio Frequency Identification Reader Writer

The Ultra-High Frequency has been used in this study due to its good performance. Radio Frequency Identification Integrative long-distance UHF card reader of reading range up to 6 m

and frequency range of 902- 928 MHz can read a big number of tags per second which at the end speed up activities.

2.7 Related Works

Several types of researches have been done and come up with different computerized methods to be used for overcoming limitations caused by Manual Library Management System (MLMS). Barcode technology is one of a computerized systems which involves the use of software and hardware and is adopted in many libraries. Singh and Sharma (2015) designed a system-based barcode identification to time-consuming and overcoming others challenges found in the manual systems (Edwards & Orukpe, 2014). However, this system is exposed to a lot of limitations and requires a physical sight to scan a barcode which involves human intervention. Also, the system cannot read more than one barcode at once and its readability can be affected by moisture, dirty, absorption, packaging.

According to Padmaj *et al.* (2019) it was observed that the barcoding technology disposes a lot of limitations and researchers recommend this technology to be replaced with an efficient system. A system-based Radio Frequency Identification (RFID) technology that uses radio waves was proposed as the best method for automating library activities, tracking, and recurring fault (Makhija & Chugan, 2016). However, the system was hindered by the issue of cost- effectiveness due to the use of UHF gates.

Furthermore, Hamid *et al.* (2012) described that there is no perfect system for actual tracking of books in the library and display their location. For that reason, the system was developed based on UHF readers that can read a tag at a high distance compared to other frequencies. Ultra-High Frequency Radio Frequency Identification tag was placed on the shelves and a big number of RFID readers was used. A similar system has been developed by Makhija and Chugan (2016) to pilot a university library. The study used Graphical User Interface (GUI) to support all necessary library functionalities and user needs. Shelf antennas that were optimized with a target of maximize tag readability as well as minimizing the pollution of electromagnetic in the vicinity cabinet were used (Yuan & Yu, 2012). However, these systems were deployed at a high cost due to the requirements of confined reading area and positioning ability to know where the label is along to the shelf.

Moreover, libraries around the world are confronted by theft which is affecting archives of different types, financial as well as academic objectives. Thus, several methods and strategies

including professional guidelines establishments, internal control procedures, training for employees, and ethical standards have been used for fighting against theft of library items and their harms in library (Scott, 2000). Contrariwise, theft is persisting. Hamid *et al.* (2012) designed a system by using RFID technology to secure library items. The system designed a real-time notification of theft using multi communication between reader and transponder. Ultra-High Frequency Radio Frequency Identification gate readers (portal) were placed at the entrance of the library for monitoring all outgoing and incoming bags and generate an alert if a non-issued library item is detected. However, the implementation of this system becomes very expensive due to a high price of the UHF RFID gate reader.

Mansfield (2009) observed that books and books pages were disappearing at the university of Lincoln due to the bad behavior of employees and users. Regular library checks in, security gates, and maintenance to avoid failures were recommended. According to Alexander (2010) bag searching acts as a deterrent and heightens security awareness. However, this approach didn't succeed to put at the end of theft activities. Furthermore, Isebe (2014) highlighted that in medicine domain is better to prevent than treat. It is the same in a library where good preventives measures have to be taken for the purpose of preventing information losses and library materials (Urhiewhu *et al.,* 2018). Therefore, solutions that incorporate technologies such as CCTV cameras and UHF RFID were recommended to be used. It helped to prevent the theft of books, to identify page removal using video records, and enabled librarians and users to execute library operations using RFID modules with no more typing.

CHAPTER THREE

MATERIALS AND METHODS

3.1 Research Design

A library is one of the important parts of academic sectors as well as professional's sectors. Students, lecturers, and researchers gain services and tools needed for conducting their works. Good management is needed to facilitate users having 24h/7 accessibility to the information resources and services provided by libraries. However, several libraries in the EAC region are facing challenges which in the end have negatives impacts on information availability, financial part as well as support on academic's curriculums. The aim of this system is to speed up all library transactions, improve the customer's satisfaction and keep a track of all library items, enable librarians to have videos records of all library operations which can be used to identify page removing actors and other unwanted behavior for the East African region. Several tasks were undertaken to accomplish this study such as assessment of existing methods for knowledge keeping, documentation, and survey, requirements analysis for system development, and validation of the developed system.

3.2 Sample Size and Sampling Technique

During data collection, the study employed a non-probability sampling techniques sample size, where 65 students and researchers and 40 librarians were involved to make a total of 105 survey participants. The non-probability sampling method is based on a subjective judgment of researchers rather than random selection (Taherdoost, 2016). A part of the sample, unstructured face-to-face interviews have been done which involved librarians of Information Centre Resources and Hope Africa University librarians.

3.3 Case Study

The study was carried out in the East African region, due to COVID-19 complications which induced countries to close borders and take others preventives measures libraries of two countries. The Information Resources Centre (IRC) located at East Africa Community secretariat Arusha-Tanzania, and in the Vivian A. DAKE Memorial library of Hope Africa University in Bujumbura-Burundi were used. The IRC was the place where I conducted my internship, and the developed system was implemented and tested in this library.

3.4 Data Collection Methods

On carrying this study, data was gathered from library staff and other users to determine challenges and needs for library management. The collected data were classified into two categories which are primary and secondary data. Primary data are those which were collected afresh and for the first time and thus happen in the original form, not published yet, and more reliable. These data are mostly obtained by interviewing the concerned people, using surveys methods, observation methods. While secondary data were collected from the published materials.

3.4.1 Primary Data

The primary data were obtained from librarians of the Information Resource Centre of EAC located in Arusha Tanzania, and from library admin and students from Hope Africa University (HAU) located in Bujumbura city, a quarter of Ngagara II. Discussion, observation, interviews, questionnaires and face-to-face conversation are the methods used to obtain all needed information. A discussion method was conducted to Information Resources Centre and Vivian A. DAKE Memorial library to assess the existing system and determine the weakness and strengths. The observation was conducted to both libraries to observe how services were delivered to library patrons and library operations while the interview was conducted to librarians to investigate scenarios which libraries were going through in embarking on an automation library. Furthermore, the questionnaire was conducted to librarians and students of HAU university to identify the level of student's satisfaction and challenges met when they visited the library. Google form was used as the technical tool to capture data from respondents. Also, face to face conversation method was used when interviewing with the library admin to identify and agree on the requirements of the developed system.

3.4.2 Secondary Data

To grasp relevant information of the developed system documentation method was used. Books, reports, various publications, and internet articles were analyzed to identify what has been done by others researchers together with observations, recommendations and solutions proposed.

3.5 System Requirements

3.5.1 Software Requirements and Tools Used

The selection was based since it is stable, supports more features, and user-friend ness. Others tools used to develop the library web-based focused on the front end, back end, and programming editor.

a) Front End Programming Languages

In programming technology, the front end refers to the interfaces of a website or software programs that are presented to users. Bootstrap is a CSS framework directed at responsive, mobile-first front end development mostly used in website design and contains templates for typography, tables, form, modals that help to design a website quickly. Bootstrap comprises the following programming languages.

(i) Hypertext Markup Language

Hypertext Markup Language (HTML) is a standard used to design web pages The version 5 of HTML was used due to its capability of standardized features such as web socket protocol responsible for a full-duplex communication in web technology. It accepts assistance from Cascading Style Sheets and JavaScript technologies.

(ii) Cascading Style Sheets

Cascading Style Sheets (CSS) is a style sheet language used to make web pages written in HTML in presentable form. It is also a mechanism of adding style in a web document such as color, font, spacing. This language was used in this study to design the look of frontend interfaces of LMS.

(iii) JavaScript

Java script is a high-level client-side scripting language used in web page development. It is a suitable tool for making a web page dynamic form and has first-class functions. JavaScript is a multi-paradigm language that supports object-oriented, imperative, and functional programming styles.

b) Backend Programming Languages

(i) CodeIgniter

CodeIgniter is a PHP Model view controller (MVC) framework and open-source software used for developing a web application rapidly. It provides out-of-the box libraries for connecting to the database and performing a various operation like sending emails, uploading the files, managing sessions.

(ii) My Structured Query Language

MySQL is an open-source, reliable and compatible with all major hosting providers, and cost-effective (Čapligins & Ermuiža, 2016). It is easy to use and has been known as the best tool for the relational database management systems (RDBMS) and is based on structured query language reason why it has been chosen to be used in this project. It will enable users to request information by simply typing the specified SQL statement on MySQL.

(iii) XAMPP Server

XAMPP is a free and open-source cross-platform (compatible with all types of computer hardware and software) web server solution stack package. Developed by Apache Friend, consists mainly of the Apache HTTP server, Maria DB database, and interprets for scripts written in the PHP and Perl programming languages. It is known as a local web server that provides a suitable environment for PHP, SQL. In this system, the XAMPP server hosts locally all data entered in the system.

(iv) Sublime Editor

A sublime editor is sophisticated text editor mostly used among web developers and natively compatible with many programming languages. It disposed of features such auto-indentation, a sidebar that enables it to easily work with the code base and allow developers to keep a track of changes. Finally, sublime is an open-source and has a version like 3.0 which is compatible with different types of operating systems like Windows, Linux, and Mac OS.

3.5.2 Hardware tools used and their specifications

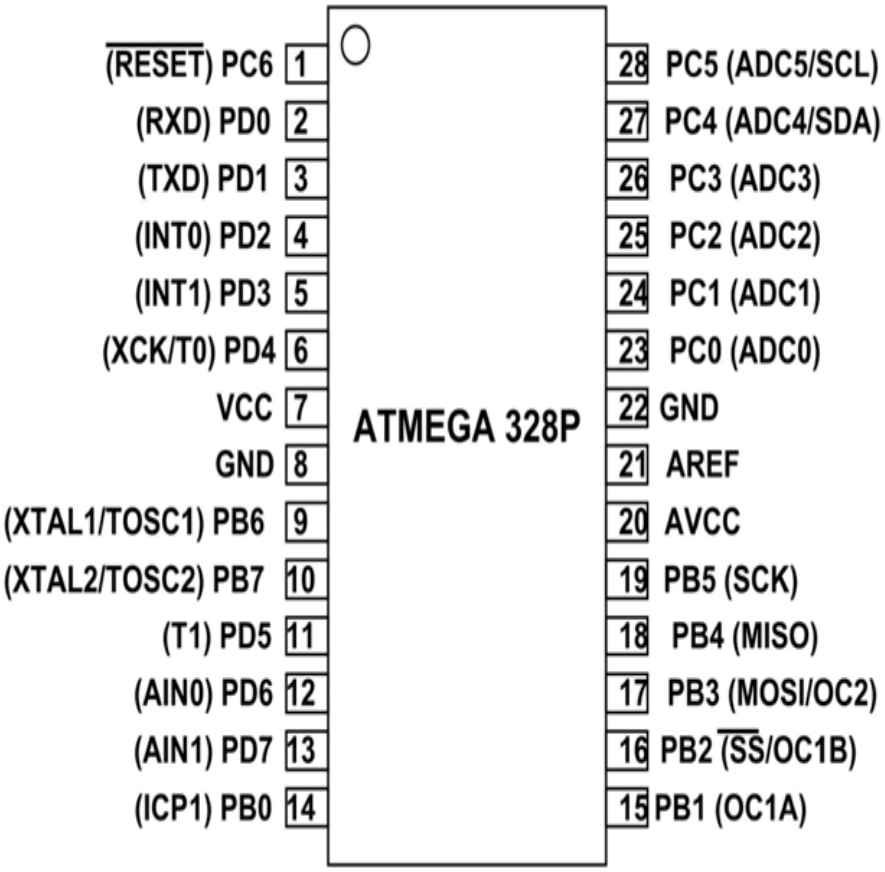
a) Computer

During the development and testing process of developed system a computer of P6100 @ 2.00 GHz with windows operating system of 64 bits and Linux operating were used. These are the minimum requirements to be considered for computer the system can be installed.

b) Microcontroller

ATMEGA328P Microcontroller is high performance, low power controller from Microchip, designed with 8bit microcontroller based on AVR RISC architecture. It is mostly used in low powered and low-cost projects and autonomous where microcontroller is required. Arduino AT mega 382P has 28 pins chip in total, analog, digitals, power and ground pins as shown in the Fig. 7. These pins are used as input for transmitting and receiving data from an external device and Pulse Modulation Width used to transmit entire signal in pulse modulation. The analog input pins are 6 named at Arduino board A0 to A5 used to process continuous time signal with an operating power range of 0V to 5V.

Digital pins are generally deal with non-continuous time signal to process signal with discrete input pulses and have representation of 0’s and 1’s. Theses digital pins are 12 and can be either ON state or OFF state.



.

Figure 7: AT Mega 328P Microcontroller Chip

c) Radio Frequency Identification tag for users

Figure 8: Radio Frequency Identification Tag for Users

Radio Frequency Identification Tag is a kind of transceiver device used to exchange data with RFID reader through waves. It has two main parts whose Integrated Circuit (IC) used for data

processing and storing as well as modulating and demodulating radio waves received/sent and antenna as second part. Radio Frequency Identification tags exist in two types such as passive and active. Whenever a passive tag comes in close proximity to reader, it is activated and able to read and send data to the reader by using radio signals. The second part is antenna which is used to transmit and receive radio frequency waves. In this study, UHF passive tags whose 96 bits to 1K bits storage capacity were chosen for library user. The device contains user's information and act as a unique identifier.

d) Antenna

Radio Frequency Identification antenna are responsible for emitting and receiving waves that allow to detect RFID chips. This device can be placed within reader or external device. Electromagnetic field can be generated when an RFID chip crosses the antenna field., antenna acts as a connection point between RFID tags and coupler. Depending to frequency band used, the antenna creates different wave fields and cover different distances RFID antenna are existing in different types such as:

- Circular Polarization Antenna (CPA) works in the best environments where the orientation of tags varies.

- Linear Polarization Antenna (LPA) are used when the orientation of the tag is known and controlled and is always the same. Antenna behaves like a communication media between the tag and the reader.

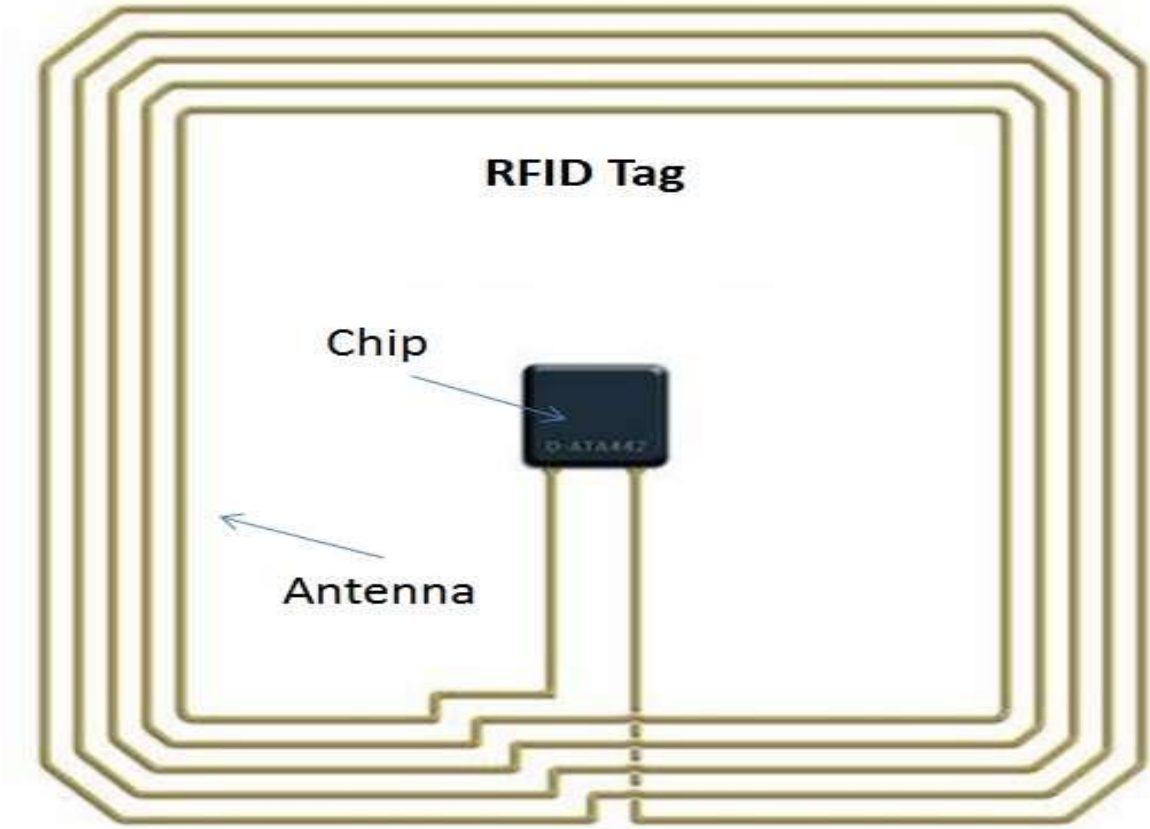


Figure 9: Radio Frequency Identification Chip with antenna

e) Buzzer

A buzzer is an electromechanical device which has 2 pins and used to convert audio model into sound signal. It is designed to operate with 5V DC voltage and used for alerting/signaling. The buzzer sound can be differently depending to design type and application. In this study buzzer was designed within both RFID readers. In Desktop RFID reader, a buzzer provides a sound when an RFID tag is detected while in the Integrated UHF RFID reader will alarm when a non-issued item is detected depending on hardware programming.

Figure 10: Buzzer

f) Light Emitting Diode

Light Emitting Diode (LED) is a semiconductor that emit light when a current pass through it. Light Emitting Diode is composed by two electronics elements known as electrons and holes which induce the light to be produced when are combined within the semiconductor material. It disposes two pins and operates at 3V DC voltage and used in this system as a system indicator.

Figure 11: Light Emitting Diode

g) Liquid Crystal Display

A liquid-crystal display (LCD) is an electronic device that use liquid crystal to display data from inputs devices electronically optical modulated. In most of case, LCD devices are used as user interfaces of the system. LCD disposes 16 pins, operates at 5v DC voltage and currently appear in different sizes in the electronic markets. A RC2004A is monochromatic 20x4 alphanumeric LCD able to display 20 characters at each 4 rows adopted to be used in this system.

Figure 12: Liquid Crystal Display

h) Ultra-High Frequency Radio Frequency Identification Integrated Reader VI-83TF

An Ultra High Frequency Radio Frequency Identification reader is a device using an Ultra-High Frequency band whose range is between 840 MHz and 960 MHz. It has an extended read range compared to other LF, HF readers interact with many tags at the same time and very high speed within distance of tens of meters. Often, each RFID reader has the three main parts such frequency module, antenna and control unit which emit and receive radio waves of specific frequencies and communicate in real time.

This reader is designed with some electronics components such as 7 dBi circularly polarized antenna, LED and buzzer for working status indication, multi-color LED indicator, buzzer to meet instructions in various working environments. It has features of STMicroelectronics STM Cortex-M3 core CPU processor with ultra-low power consumption and ultra-high performance which makes the reader program and interface run more stable and faster. Then a flexible and rich interface methods, standard interfaces (TCP/IP, RS485, RS232, Wiegand interface), and optional (wireless WIFI, Bluetooth). With a reading distance of 3-5 meters, this reader work within an operating DC voltage of 9-24V with an operating temperature of -20ºC～+60ºC and able to read multi-tags whose number is greater than 50 sheets /second.

Figure 13: Ultra-High Frequency Radio Frequency Identification Integrated Reader

i) Ultra-High Frequency Radio Frequency Identification Book archive tag LA-86C

Linearly polarized design provides ultra-high read rates in a particular direction and high senility identification, RFID labels have a high security performance, a global unique code

identification and widely used libraries, database rooms and secrets archives. The LA -86C, was designed in Ultra-High Frequency categories with a working frequency of 860-960 MHz, a working temperature of -20℃~+50℃ and retention time of more than ten years (>10 years), able to read and transmit data within a reading range of 0-5 meters depending on reader's performance.

It disposes a storage capacity of 96 bits, dimension of 98*6 mm and readable writable working mode.

Figure 14: Ultra-High Frequency Radio Frequency Identification Book Label

j) Radio Frequency Identification Desktop Reader VD-67

Compatible with multi-protocol (ISO 18000-6B, ISO 18000-6(EPC G2), small size, fast read rate, good design and other advantages. Radio Frequency Identification Desktop Reader has the operations of keyboard emulation, powered by computer USB port and RF lights and beeps. It works with a temperature of -20°C to +60°C and reading distance of more than 100 mm and more than 50 mm for writing. The desk RFID reader is widely used in many domains.

Figure 15: Radio Frequency Identify Desktop Reader

k) RS-232 Cable

In communication system, RS232 is used for serial communication between data terminal equipment (DTE) and data circuit-terminal equipment (DCE). In this study, RS-232 was used to facilitate communication between readers a computer system.

Figure 16: RS-232 Cable

l) Ultra-High Frequency Handheld Reader

Ultra-High Frequency handheld reader is made with portable RFID device with lightweight and battery-driven. It is usually often built to provide ergonomic comfort. It operates in a good frequency reading range of 915 MHz. Unlike a fixed RFID reader, which needs to be fitted and cabled, handheld reader is mobile and can be carried to tag an embedded in designed location. Also, most of handheld readers have key features that enable data collection and transfer by translating RFID code without having RIFD middleware needed for fixed RFID readers.

Figure 17: Ultra-High Frequency Handheld Reader

m) Closed Circuit Television Camera

The Closed-Circuit Television Camera (CCTV) also known as video surveillance pick up images and video which at the end are sent to recording device then displayed through monitor screen.

Figure 18: Closed Circuit Television Camera

n) Network Video Recorder

Network Video Recorder (NVR) is a digital device used to receive live images and video streams and store them digitally on hard disk (HDD). In this study, NVR was selected due to high video quality, able to supports different types of cameras while DVR accepts only the analog camera. Besides, DVR while performing functions requires cameras to be wired while, NVR record remotely in a wired mode.

Figure 19: Network Video Recorder

o) Closed Circuit Television Monitor

Closed Circuit Television (CCTV) monitor is the display device usually connected to surveillance video recorder. Most of DVR and NVR devices dispose ports which are compatible for VGA, HDMI, and DVI connection.

Figure 20: Closed Circuit Television Camera Monitor

3.5.3 System Block Diagram

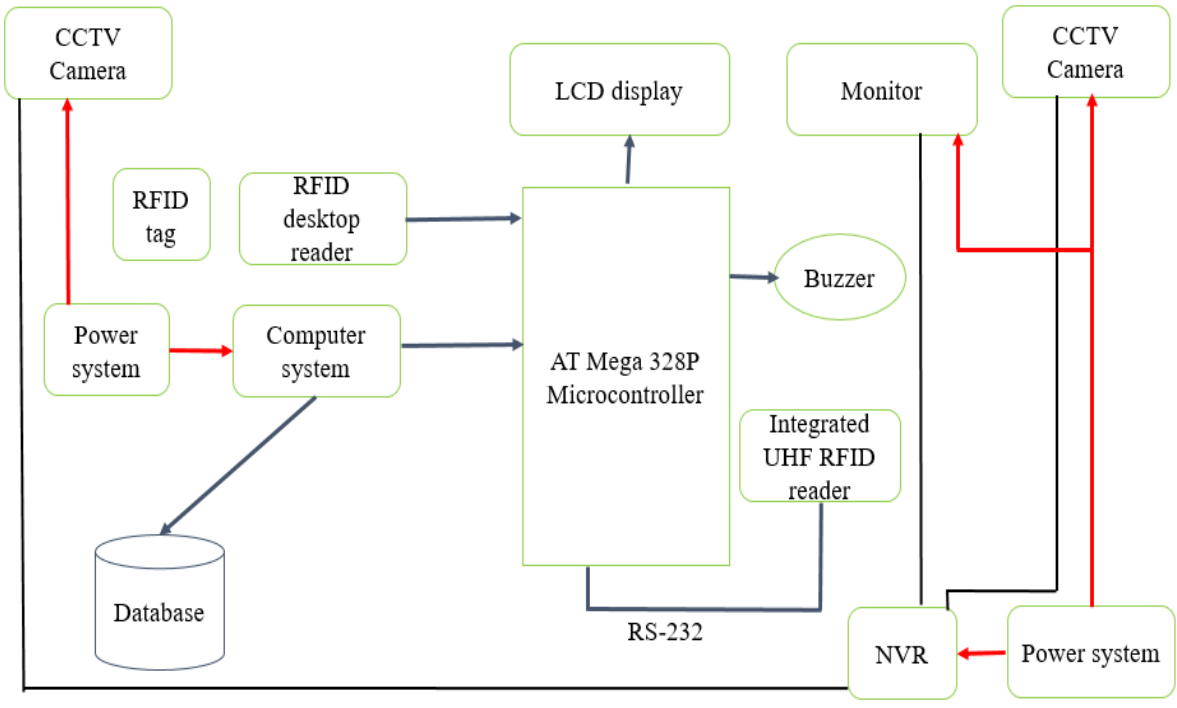


Figure 21: System Block Diagram

Figure 21 shows the input and output devices integration. At the center of the system, there is a microcontroller which coordinate each activity, compile the code and producing the output. The relay component was used to control the circuit diagram and provide a necessary amplification of converting small current into a large one.

3.6 System Development Approach

System Development Life Cycle (SDLC) methodology was used to develop this system. The SDLC involves 5 phases which can be extend to 7 mastering phases. It tracks a project from idea generation to system validation. The SDLC involves comprehensive and explicit steps such as 7 mastering phases:

(i) Requirements gathering stage
(ii) Feasibility stage
(iii) Design and prototyping stage
(iv) System development stage
(v) System implementation and integration stage
(vi) System testing and maintenance stage

a. System Validation

The used phases in this development applied the V model. The V model is one of the methods of SDLC considered as the extension waterfall method which involves the finishing of first step and shift to the second. System Development Life Cycle has been chosen to be used in this project due to its advantages of giving a defined view of the entire system, resources, timeline and goals. During design process, this method provides the ability of reviewing feature and help to ensure the reliability of quality of the final product.

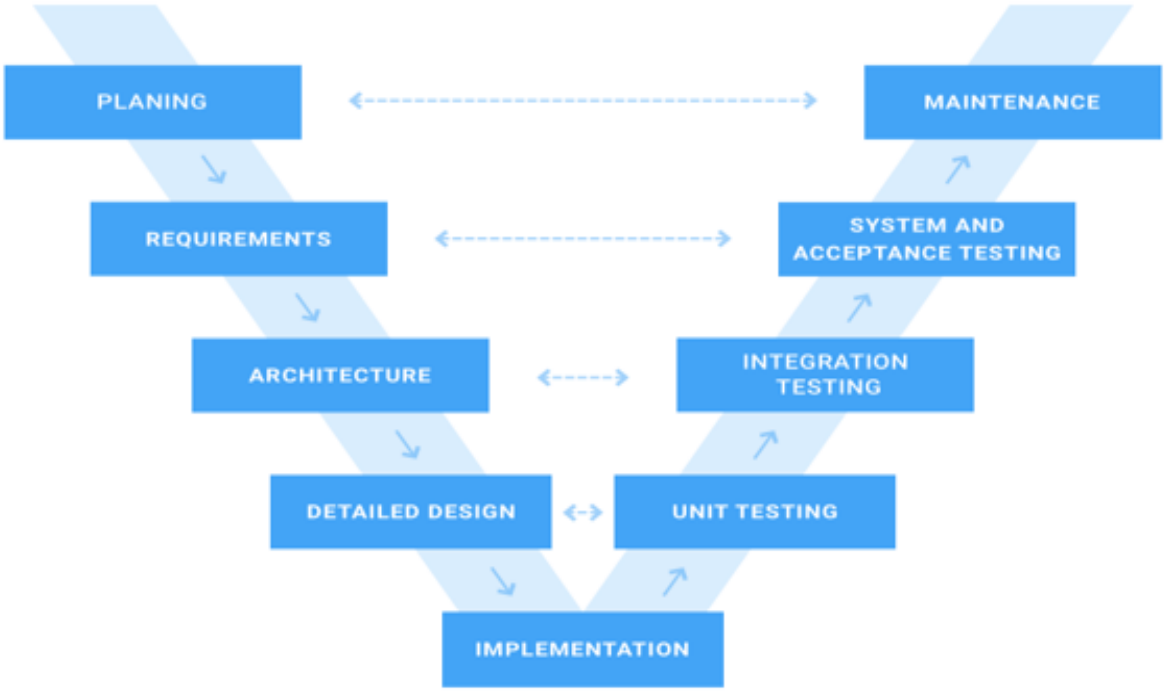


Figure 22: V-model

Figure 22 demonstrates the relationship between each phase of the methodology used to develop this system. It is important part of system development since it makes a system more visible. After determining the requirements, the process of designing, development, implementation follow with respect to the context of waterfall. Therefore, in V model, each phase of verification has its correspondence in validation. The following phases have to be done before validating a system.

(i) Unit Testing

Unit's testing is generally done automatically in system development to ensure that the section of the system (known as unit) meets its design and behaves as intended. Unit testing also verifies that the smallest part of the system can work properly when it is isolated from others.

(ii) Integration Testing

The integration testing was developed during the architectural design. These tests were done in order to ensure that the created units and tested independent coexist and communicate among themselves.

(iii) System Testing

Different to unit testing and integration testing, system testing deals with the whole system. A team of the library stakeholders tested the functionalities and independencies of the developed system to ensure that the system requirements have been met.

(iv) User Acceptance Testing

Finally, the user acceptance testing was executed in the user environment. It verifies that the delivered system provides efficient services in a real time and its performances to ensure that users requirements have been responded.

3.7 Data Flow Diagram

3.7.1 Context Diagram

In engineering, data flow diagram is tools that illustrates the flow of data through the interaction of different entities of the system. It is a graphical depiction of the flow of information and the data that are applied to the movement of data from the input to output. Figure 23 depicts the interactions between LMS and external entities and Fig. 24 illustrates the logic of producing output with the exploding of level 0 in order to get level 1 of data flow diagram (DFD). The others Figs. 25, 26, 27, 28, 29 and 30 demonstrate the processes of user login and context of other library processes.

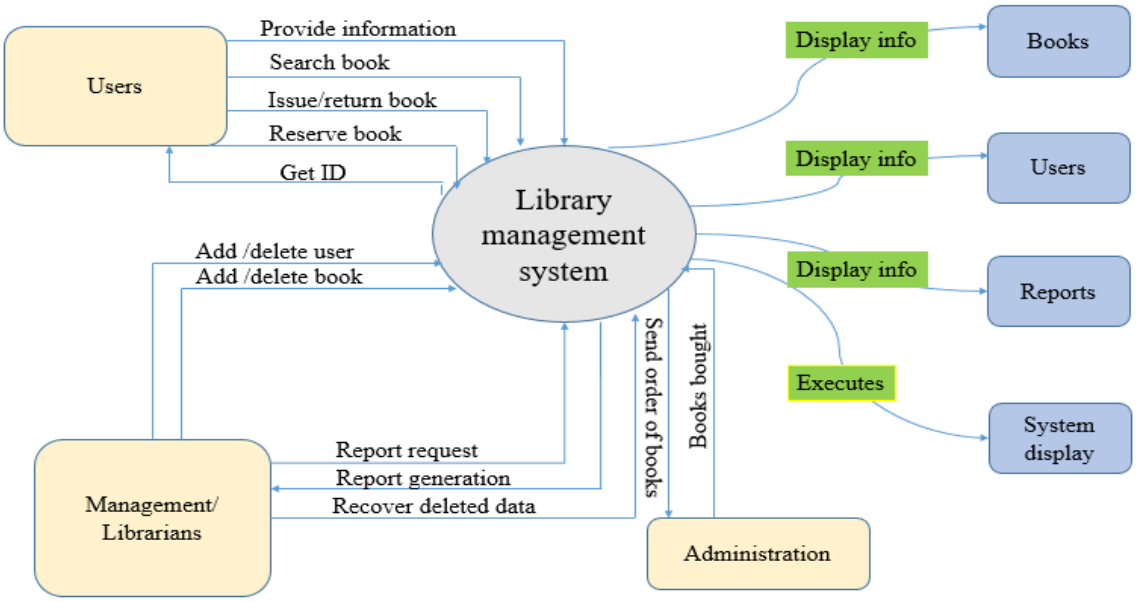


Figure 23: Context Diagram

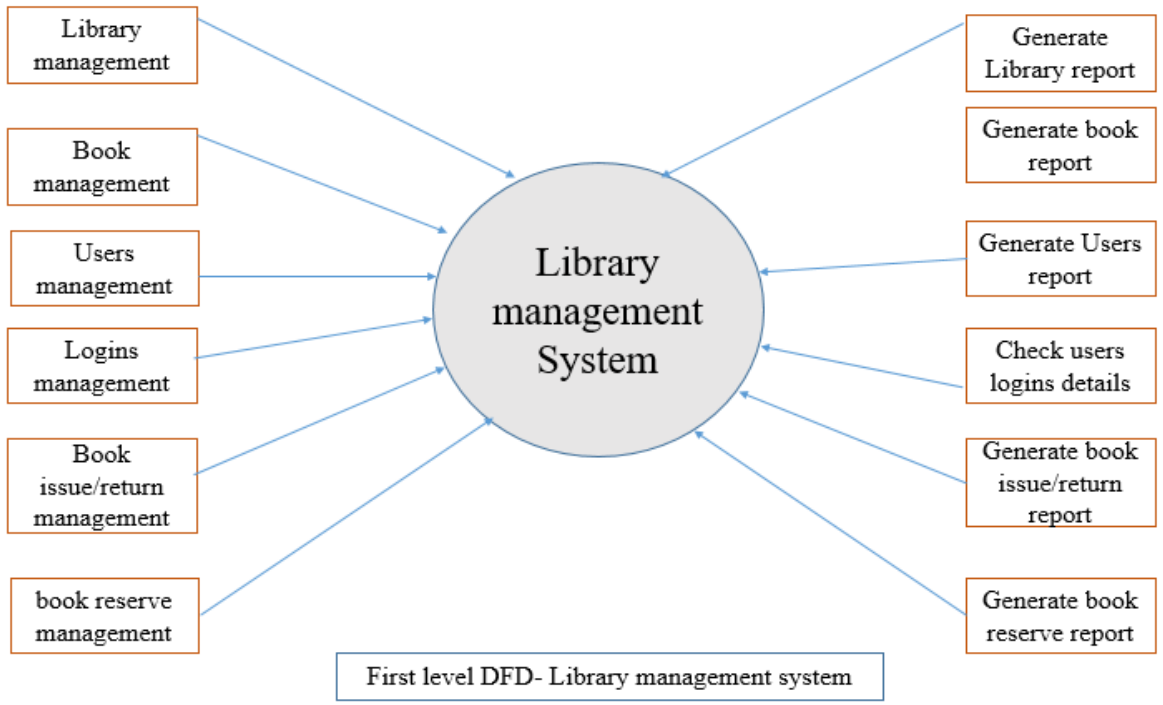


Figure 24: Data Flow Diagram of Library Management System

3.7.2 User Login

At the home page of the system, user will be asked to click on login link. When done with the selection, user will be directed to a panel and provide the credentials information (username and password). The system checks validity of the provided information in database, will then grant access or require user to register.

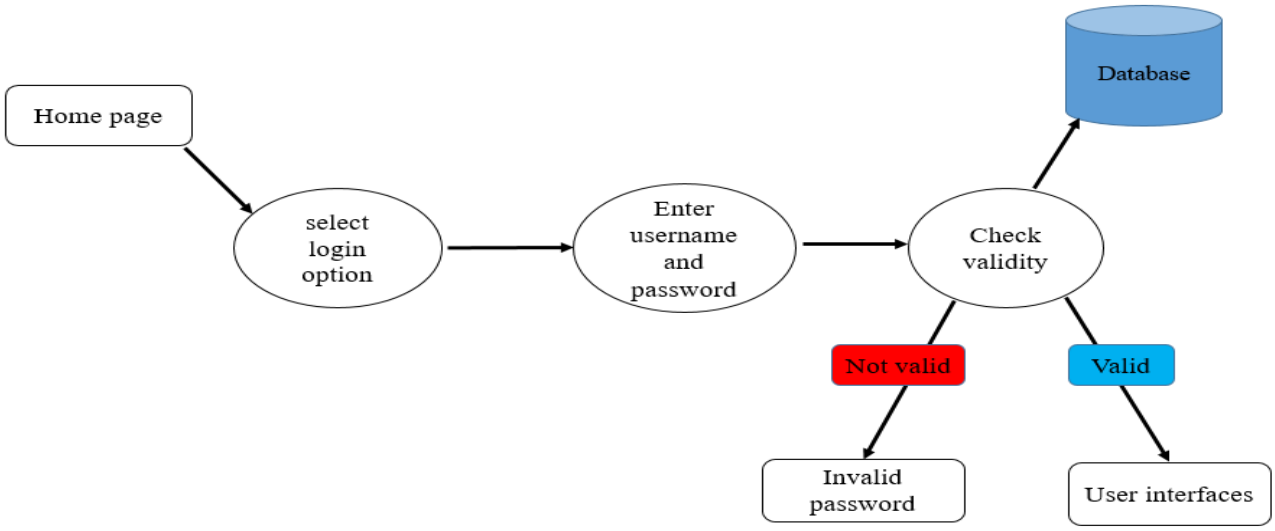


Figure 25: Data Flow Diagram for User Login

3.7.3 Admins Login

After entering user credentials, system verify the user profile the present her/his related interface. The admin interface enables to have privileges and rights for monitoring all users and entire system.

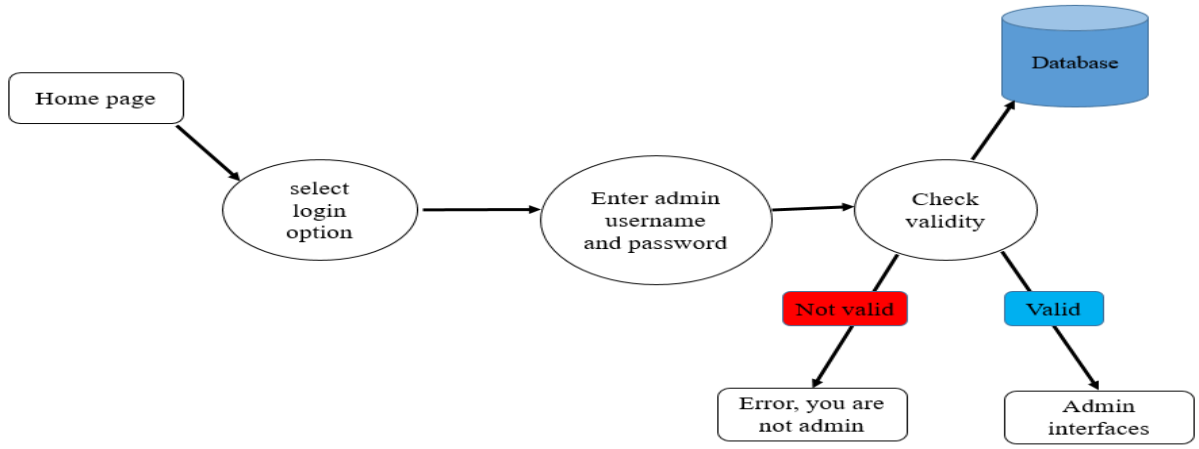


Figure 26: Data Flow Diagram for User Login

3.7.4 Super-admin Login

Super admin is an admin with all privileges and rights in the system administration in addition of database access.

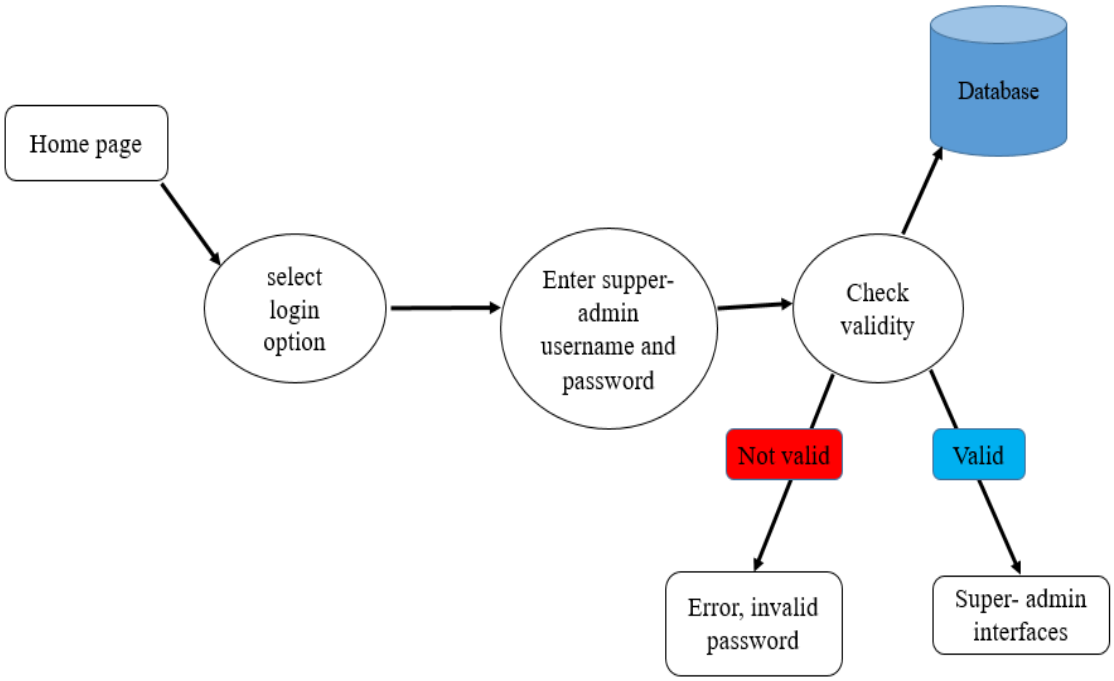


Figure 27: Data Flow Diagram for Super-admin Login

3.7.5 Account Creation

The super-admin and admins were granted right to create users accounts. For user's accounts to be created, requests have to be sent to admins. The system requires admins to create account and grant username and password to users. Also, RFID smart card was provided to users to assist the process of borrowing books.

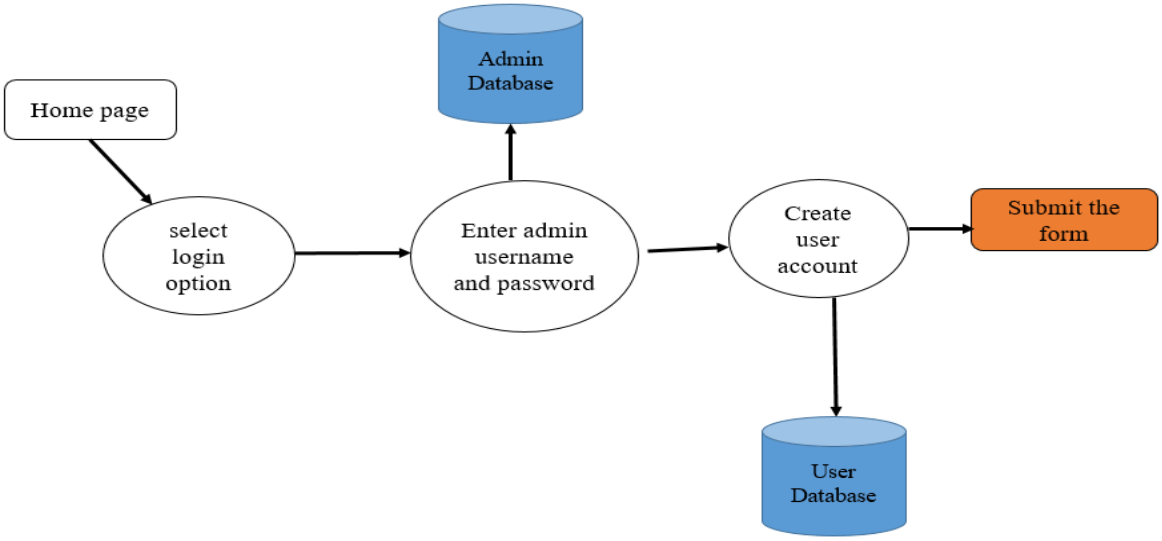


Figure 28: Data Flow Diagram for Account Creation

3.7.6 Borrow Book

To borrow a book both super-admin and admins will be required to login as users. After checking if the desired book is available, they will click on borrow button and complete the borrowing form by scanning the user RFID tag and books. If the scanned user ID tag is identic to the one stored in the database, user will proceed with scanning the book. If card IDs are not matched, user will get an error form.

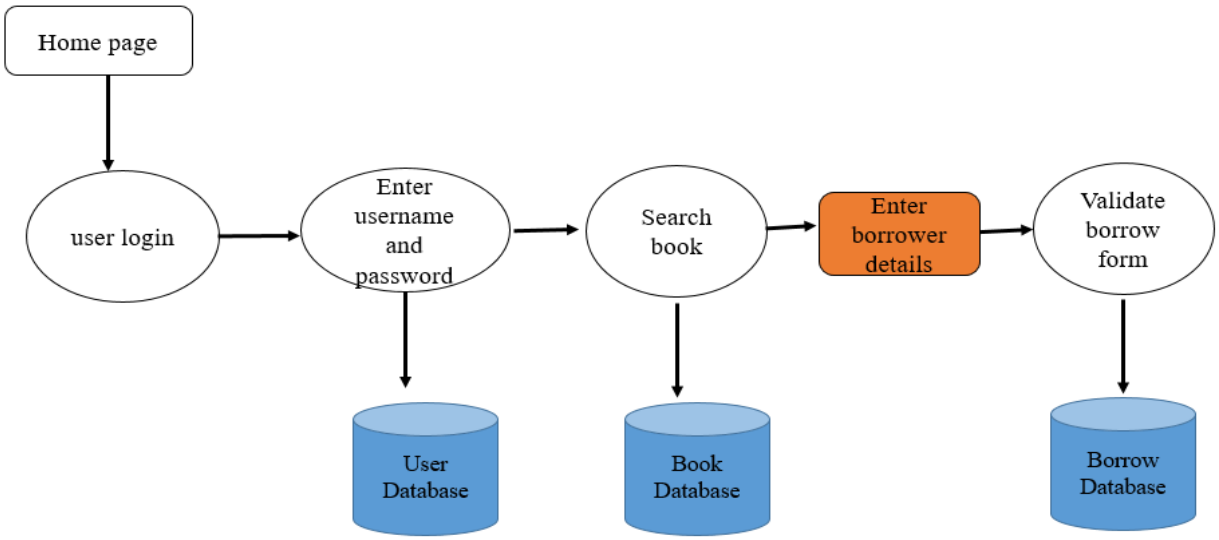


Figure 29: Data Flow Diagram for Book Borrow

3.7.7 Book Search

Each authorized user will be able to search books by entering the key word and view the details such as author name, name of the book, year of publication, publisher, abstract and book status.

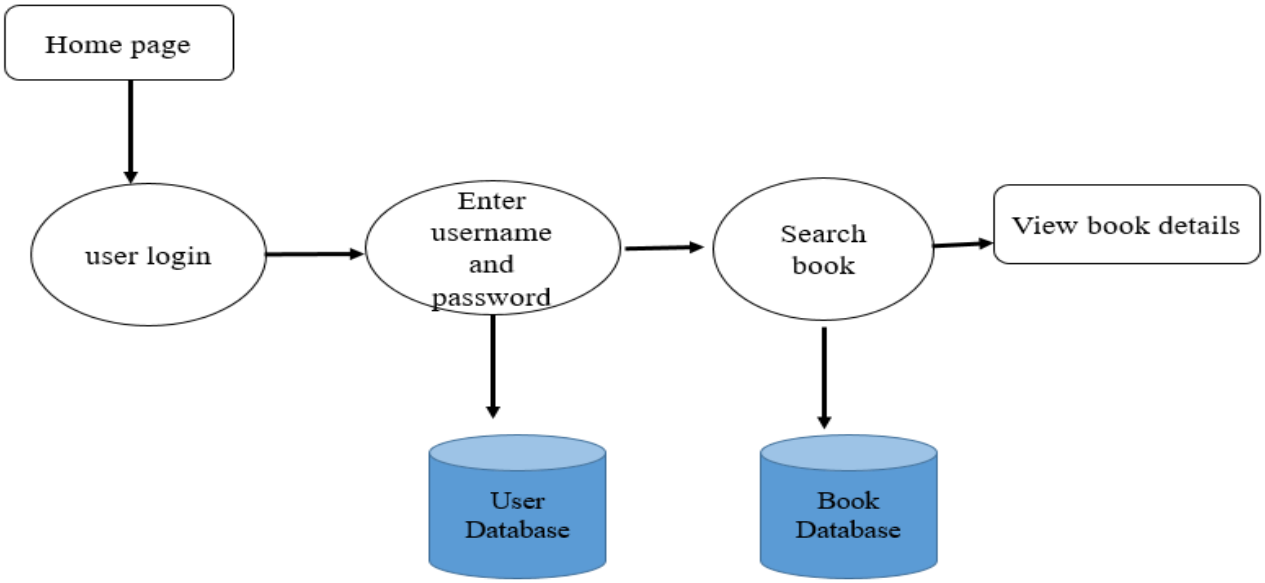


Figure 30: Data Flow Diagram for Book Search

CHAPTER FOUR

RESULT AND DISCUSSION

4.1 Finding Obtained from Primary Data

4.1.1 Demographics Characteristics

Assessment demographic of respondents in this study was very inevitable to assess attitude and prospective of library stakeholders through the use of Information and Communication Technology (ICT). This study examined gender, age, education level and experience of using internet and library. Table 3 demonstrates the socio-demographic details of each category of respondents. The total number of 105 respondents were examined with number of male greater than number of female respondents.

Table 3: Demographic Characteristics of Respondents

	Demographic features	**Respondents**	**Percentage %**
Gender	Male	62	59
	Female	43	41
Ages	Under 18	1	1
	18-30	57	54.3
	31-40	41	39
	41-60	6	5.7
	Above 60	0	0
Education	Secondary	6	5.7
	Bachelor	46	43.8
	Masters	36	34.3
	PhD	17	16.2

4.1.2 Existence of Libraries and its Use in EAC Region

Figure 31 shows that libraries exist at 95.2% in the EAC region academic institutions. Also, Fig. 32 illustrates 27.8% of respondents visit the library several times a week while 2.6% of respondents visit library rarely. Figure 33 demonstrates purpose and reason for visiting the library. The results show that 82.9% of respondents visit library for the purpose of finding a books or magazine while 11.4% of respondents visit library to use audio-visual equipment.

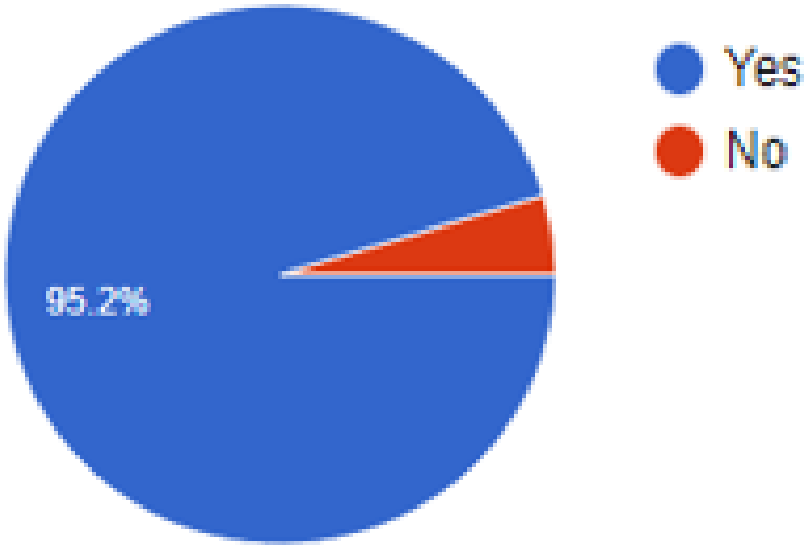


Figure 31: Existence of Library in Academic's Institutions

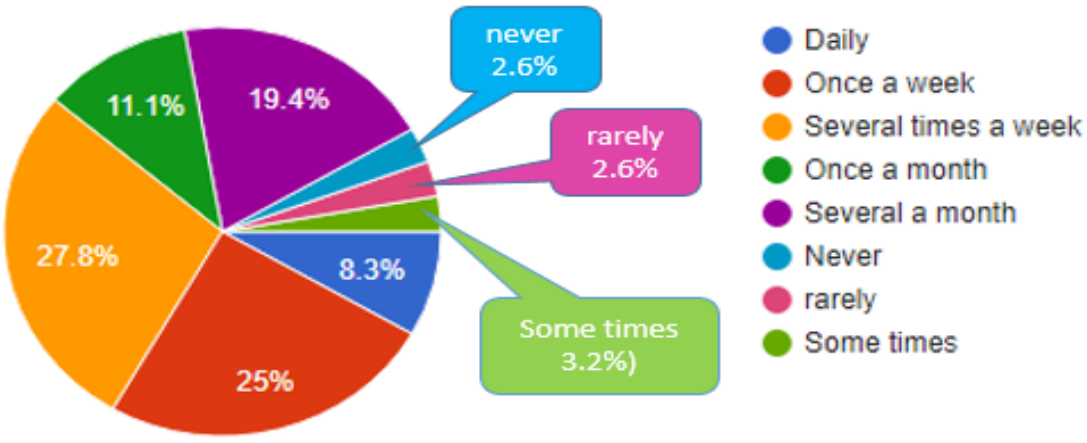


Figure 32: Number of Times of Visiting Library

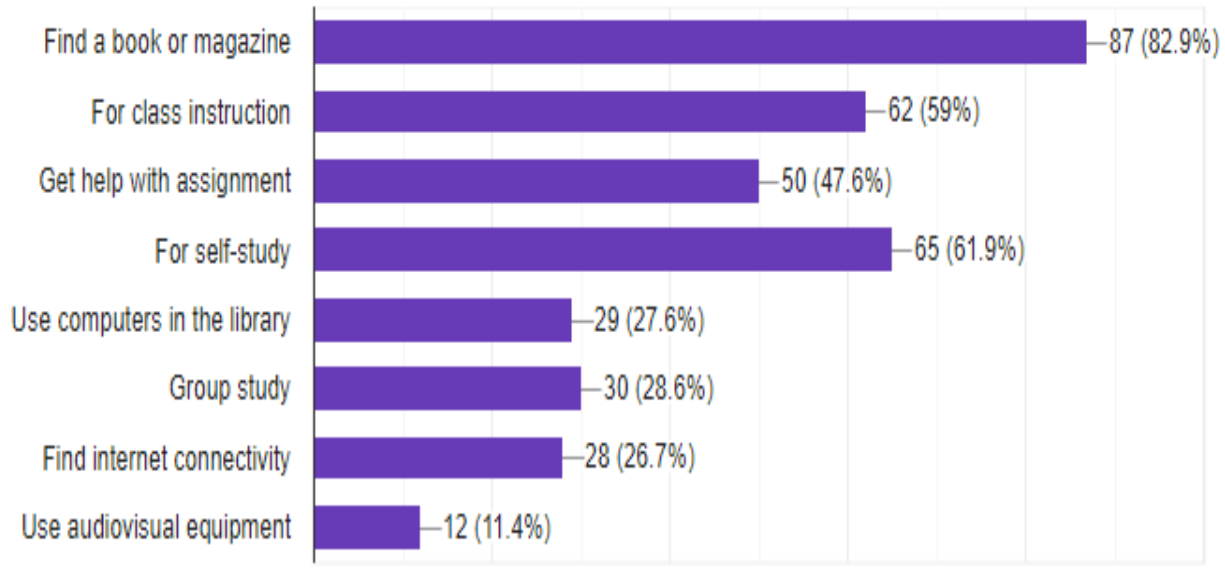


Figure 33: Purposes of Visiting Libraries

4.1.3 Library Management System Used

A survey was also conducted to identify which libraries management system were mostly used in the region. The results showed that 61% of library were managed in computerized way while 39% were managed manually. However, the data collected from respondents illustrates those libraries were using different computerized methods where software were used at 51.9% while RFID technology is used at 13.9%.

Table 4: Library Management System Used in EAC Region

Library management system		**Respondents**	**Percentage %**
Types	Computerized	64	61
	Manual	41	39
Technology used in computerized	RFID	11	13.9
	Barcode	21	26.6
	Software	41	51.9
	Q-R	0	0

4.1.4 Internet Usage and Technological Devices

A survey was also conducted to identify how internet were used in academic sector and which devices were mostly used. Results from the respondents showed that 99% of respondents accessed internet with different proportions of times. As shown in the Fig. 34, 43.8% accessed internet daily 44.8% several times a week while 1% never accessed it. Figure 35 shows devices which were used to access internet, 81.9% access internet using laptop while 19% accessed using tablet.

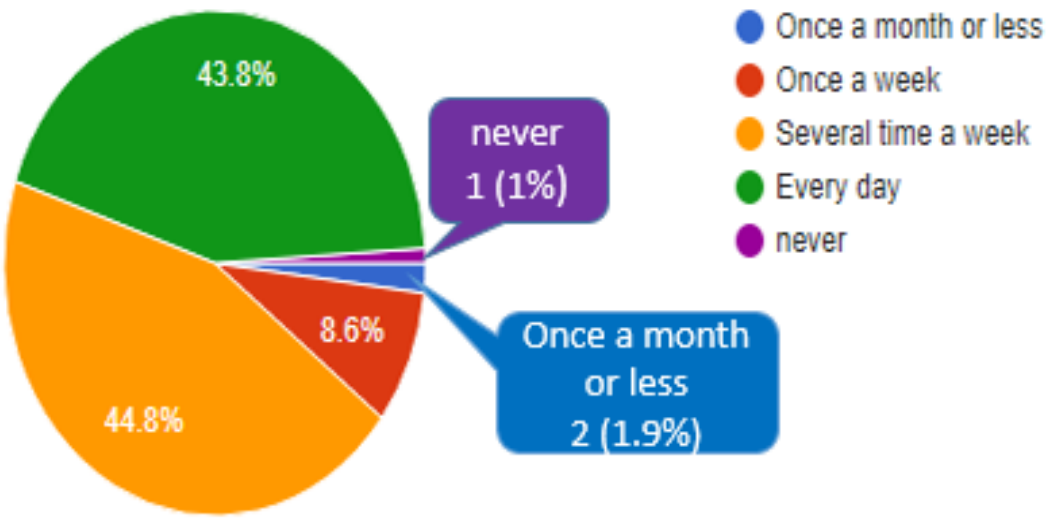


Figure 34: Number of Times that Internet is Accessed

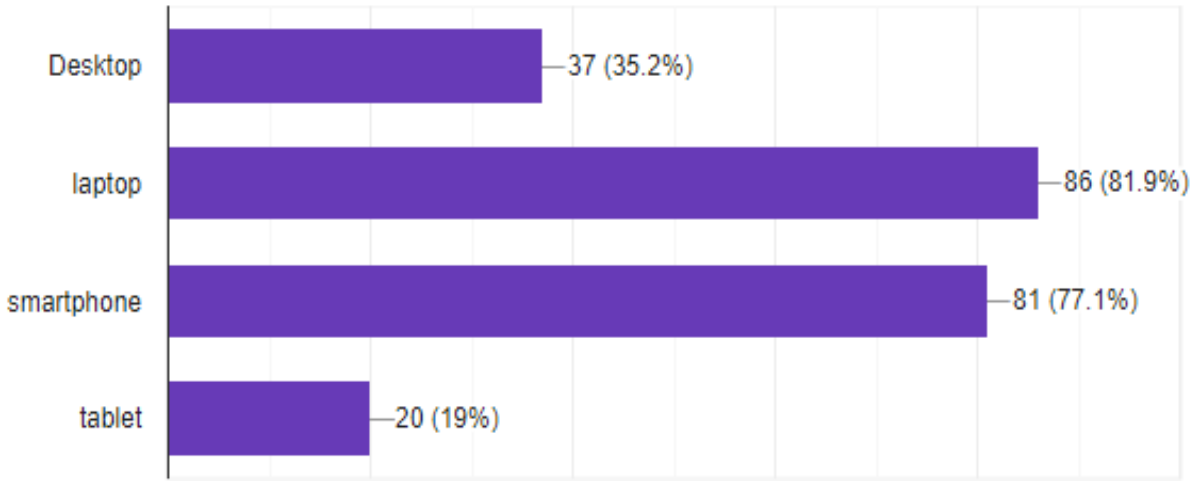


Figure 35: Devices Used to Access Internet

4.1.5 Types of Security Used in Existing System

In order to know how far library items were secured in library, a survey was conducted in the prospective department and results showed that libraries used different security measures. Results showed that measure of strictly forbid users to enter in the library with a handbag were used at 80.9% while using an alarming system at the library exit revealed 0.9%.

Table 5: Methods Used to Prevent Loss of Library Items

Methods used	Respondents	Percentage %
User's bags checking at the exit of library	65	61.9
It is strictly forbidden to enter with a handbag	85	80.9
Each user is required to sign in the library book	41	39.04
Surveillance camera	22	20.9
Guards are standing at the entrance and exit	19	18.09
Using an alarming system at the library exit	1	0.9
Librarians and guards make circulations in the library when users are inside	1	0.9
Using biometric technology to enter	12	11.4

4.1.6 Challenges in Library

In order to understand challenges facing libraries, the conducted survey showed that theft existed at 42.85% and done in several times a year, 68.57% of respondents found pages were removed. During borrowing the used time is 10 minutes which presented at 40.4%.

Table 6: Challenges Founds in Existing System

Subject	Number of times	Respondents	Percentage %
	Once a day	0	0
	Once a week	2	0.019
	Several times a week	4	0.38
Theft in library	Once a month	6	0.57
	Several times a month	7	0.66
	Once a year	25	23.80
	Several times a year	45	42.85
	Never	16	15.23
Book pages removed	Yes	72	68.57
	No	33	31.42
	Equal or less than 5 min	11	10.6
Times used in	10 min	42	40.4
borrowing process	15 min	38	36.5
	More than 15 min	13	12.5

4.1.7 Library Management System Usability and Client's Satisfaction

The survey was conducted to identify the usability of library and customer satisfaction. As shown in the Tables 7 and 9 validation aspects were used and results shows that 8 aspects have average of 21, which mean users agree that library is helpful.

Table 7: Library Management System Usability and Customer Satisfaction

Validation aspects	Number of Respondents					
	Strongly agreed	Agree	Neutral	Disagree	Strongly disagreed	Average score
Resources are appropriate for my course needs	18	62	5	15	7	21.4
Resources are easy to find	14	43	10	30	10	21.4
Resources are current and relevant	15	55	8	22	4	21.4
Borrowing resources policies and procedures are Clearly stated	18	46	4	32	5	21
I usually find the needed resources	14	38	6	40	7	21
Recommendations for new or different resources are listed by the library staff	12	46	6	36	4	20.4
The librarians provide good assistance	12	56	9	20	8	21
I am satisfied of library services	13	48	10	28	7	21.2
Internet connection of my library is very faster	13	53	9	19	11	21

4.2 Finding Obtained from Secondary Data

Findings from documentation, reviewing other related works showed that, the most of existing system used barcode, RFID technology, others used software-based library management. Libraries which used barcode technology were vulnerable to a lot of challenges due to limitations such as sight line to read, short range, ability to read one barcoding at a time. The software was good and made libraries automated however they were incompatible for theft detection. The RFID technology was used in most of cases to replace and resolves issues of barcoding.

4.3 Descriptive Analysis of Existing Systems

The descriptive analysis method was adopted to be using for data analysis in this study. This technique allows learning from the past behaviors and find out how it might influence future performance. The existing systems for library management have general purpose of making

information accessible, identifying library items and serving a defined community. Descriptive analysis method was used to identify weakness and limitations of existing systems in order to come up with solution.

4.3.1 Problem of Existing System

After observing existing library management systems both manual and computerized, the following problems were highlighted:

(i) Loss of data: In some of the systems, data are not centralized. They are kept in a book or pieces of papers which might lead to information loss.

(ii) Time consuming: Time consuming tends to differ from manual to barcoding system. Manual system takes a lot of time in report generation compared to barcoding system. Also, users cannot be tracked easily in the manual approach.

(iii) Error: Some systems such as manual and barcoding are exposed to human error due to human interactions.

(iv) Theft: library items such books, CD or others are stolen each year in many libraries around the world including that of East African region.

(v) Page removing: In some libraries, instead of borrow the entire book, users may decide to remove pages containing needed information.

4.3.2 Description of the Developed System

The developed system comprises development of software and hardware integrations. The first part provides diverse features via interfaces to help users to interact with the system. The second part focuses with integration of different hardware for the purpose of automating activities, identifying library items and enhancing security. The whole system has three categories of interfaces:

(i) User Interface

This interface allow user to login and see all available items in the library. Users will be able to search needed item, borrow, reserve, cataloging, change password and track records.

(ii) Admins Interface

Admins (librarians) have granted access to register users and library items such book, CD, and DVD. The system grants admin's ability to monitor borrowed, returned, non-returned and reserved items and make decision for anticipated behavior. Furthermore, admin can generate reports in desired format and have access to borrow book through user interface.

(iii) Super-admin Interface

A super admin is the person who has all privileges of managing all users in the system. In this system super admin have ability to add admins and grant them with all required access. Besides, super admin has ability to monitor and review actions of admins. Furthermore, the system offers super-admin access to recover the deleted information and delete it completely. This feature has been added to handle the challenge of deleting some important information, which in most cases it happens when the library has many librarians.

4.4 Radio Frequency Identification Book Labeling

Figure 36 describes, the process of book labeling and presents the view mode of labeled book. Each label disposes a dimension of 98*6 mm in such way it cannot be seen easily by users. When attached on book, it is not easily to remove unless to users remove it with the page on it is attached.

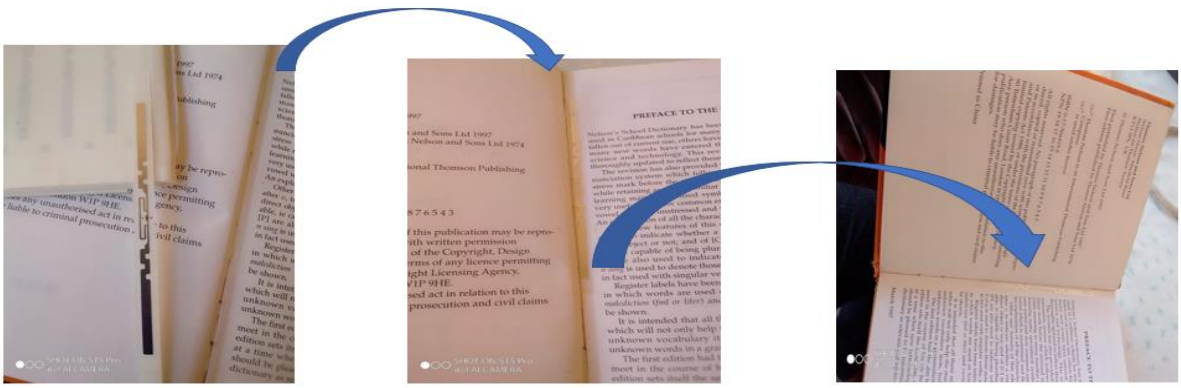


Figure 36: Book Labeling

4.5 Radio Frequency Identification based Library Management and Anti- Theft System Database Implementation

The database of this system was developed and supported by MySQL database management and PHP scripts for user's web connectivity. Figure 36 illustrates number of tables used to develop the web based of this system and associations in the application.

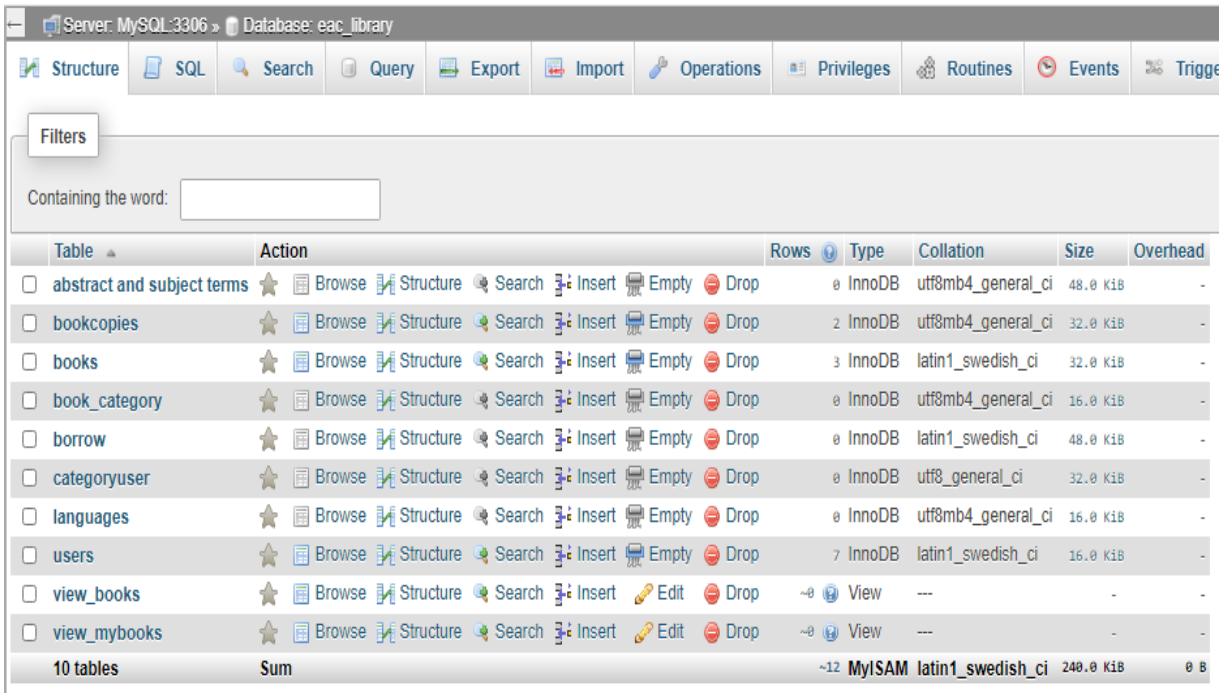


Figure 37: Database Implementation

4.6 Input and Output Design

The developed application is responsive for different ICT tools. It provides interfaces to users and enable them to login and execute their needs. Librarians get the capability of registering user, book and monitoring features.

4.6.1 Home and Login Page

The home page gives an overview of the system, it presents a login panel where each category of users is required to click on login panel (get started) and enter credentials in order to have access to the system. Users are required to be registered to have access for login in the system. Once login, user will be directed to pages containing information depending to their privileges

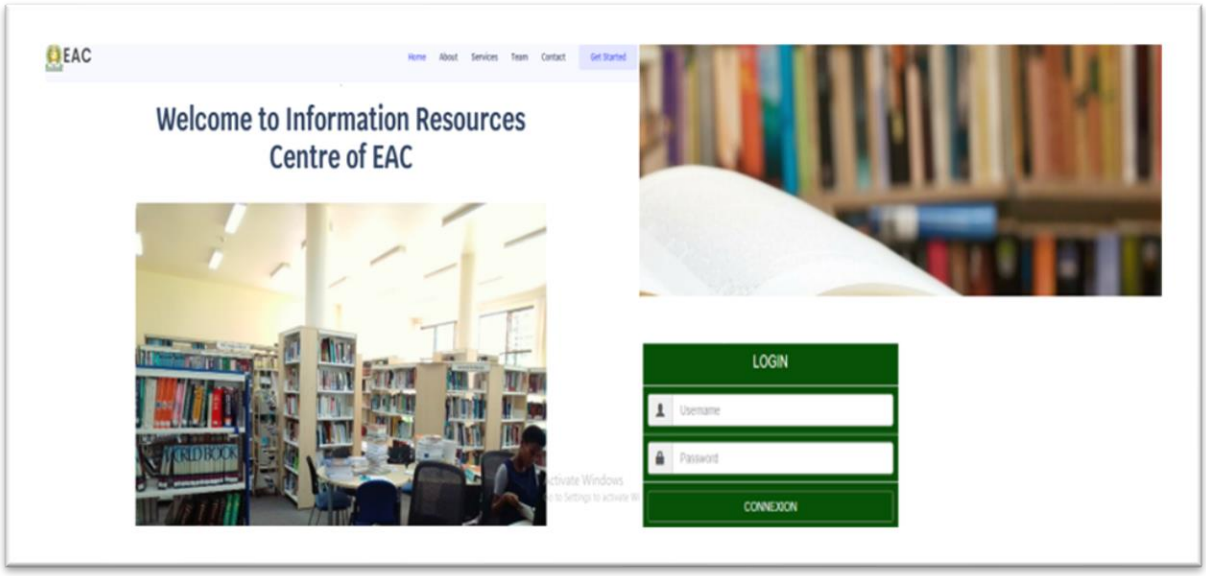


Figure 38: Home and Login Page

4.6.2 User Registration

Admins have ability to grant access to users registered in the system. Users are required to provide personal information such name, surname, telephone number, department. Librarians have ability to create for user a temporary password and give them RFID tag for identification. After being added, users can login and get access to library system as shown in Fig. 39.

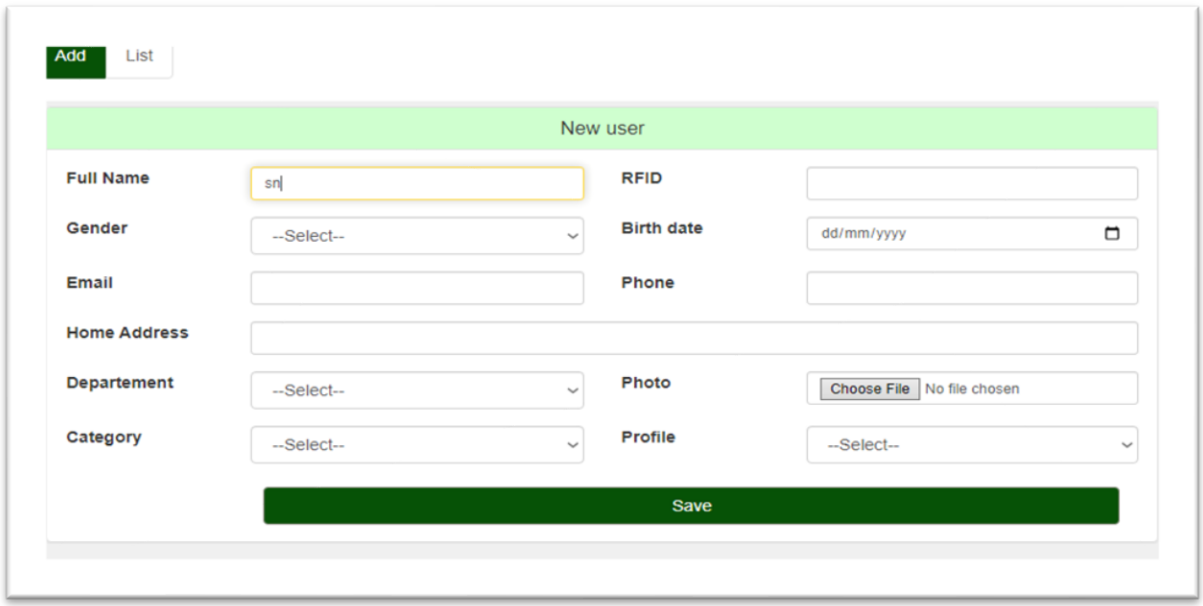


Figure 39: User Registration

4.6.3 Add Book

Admin has ability to register all library items in the system. Books details such as title, name of author, publisher, year of publication will be entered in the system and assigned the RFID ID that stored in label.

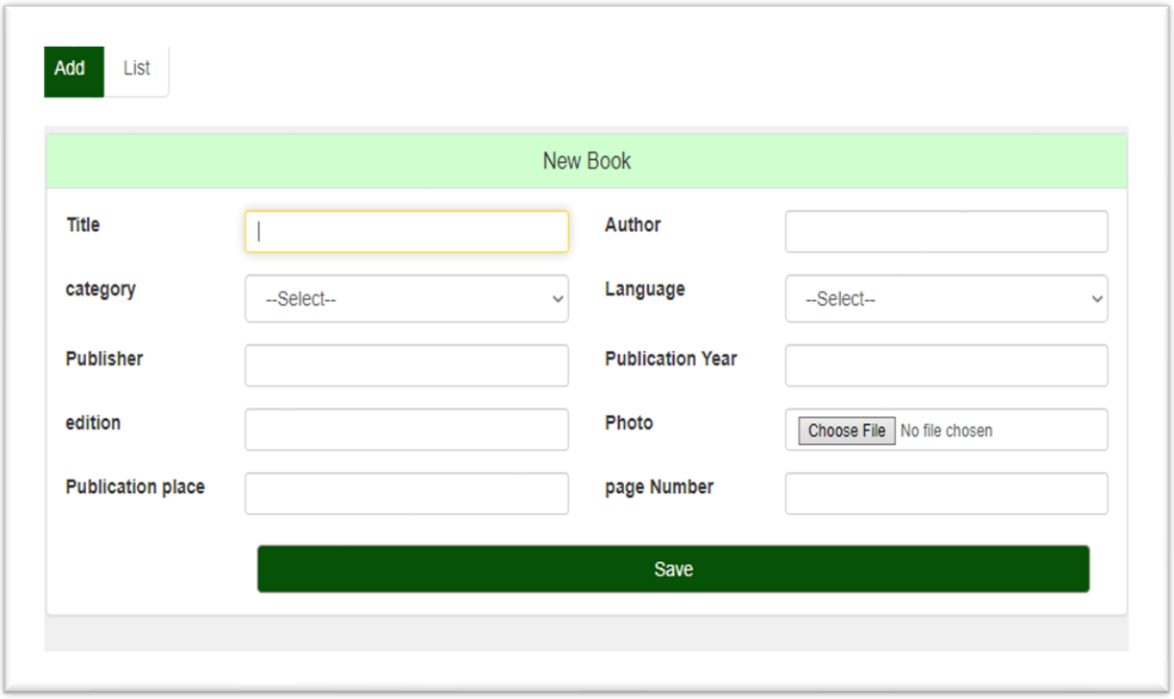


Figure 40: Book Registration

4.6.4 Book Search

After granting access to the system, users can search book by entering keyword as shown in Fig. 39. Details of book such abstract, publication year will be displayed by clicking on the view button. Also, users will be able to see the book status (borrowed /reserved/available).

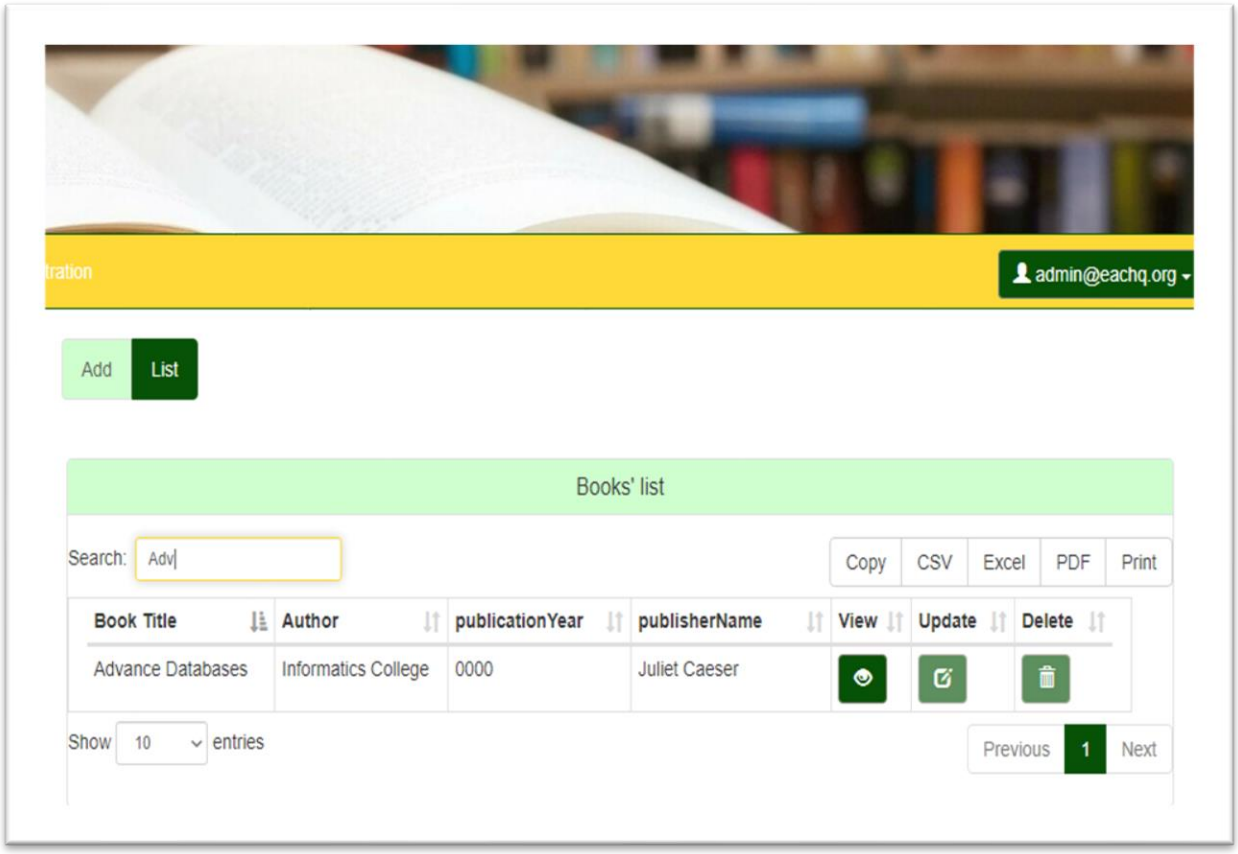


Figure 41: Book Search

4.6.5 Book Borrows

All registered users have rights of borrow book if they are available in the library. During book registration, admin specify if the registered item is allowed to be borrowed. Borrowers have only right of borrowing book copies while originals books are restricted. By clicking the borrow button, users are required to enter details and swap the tag to the desktop reader. When the ID of swapped tag is matched to the assigned user ID, their personal information such name, User Id and emails will be appeared in the form. Then, user will continue by scanning the preferred book and books details as shown in Fig. 40 will be displayed in the form final click on borrow button. However, the process of borrowing can be denied due to the following case:

(i) The allowed number of items to be borrowed has been exceeded (2 or 3 items are allowed but depending to library regulations).

(ii) Users didn't return the previous borrowed items.

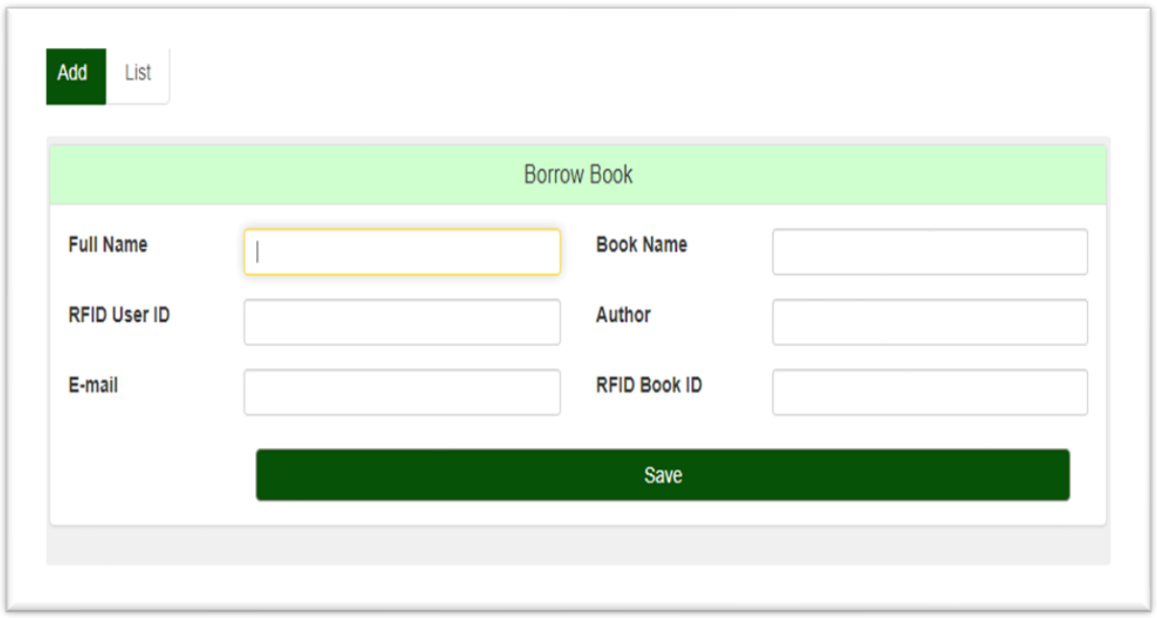


Figure 42: Book Borrow

4.6.6 Return a Book

To return borrowed library items, borrowers will be required to scan their user tag ID, then see their personal information will be displayed in the form. The borrower will proceed the same by swapping the item to be borrowed. When returning the process done, system updated automatically finally generate the return date which appear in user account history (view my book). The return date will be automatically generated by system and it can be different depending to user category. When the return date is approached, users will get notification via email reminding them to return borrowed item.

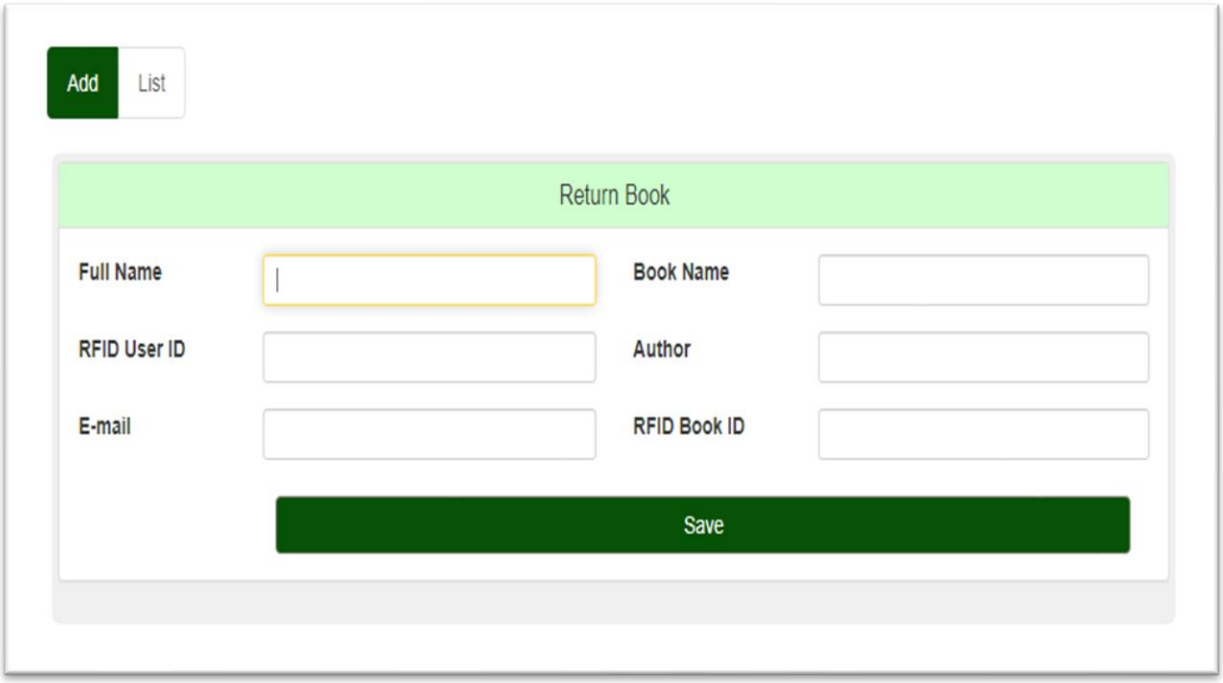


Figure 43: Book Return

4.6.7 Book Reservation

When users find book of their preference, and they are not around library, the system give them the ability of reserve the book for 48 hours.

CHAPTER FIVE

CONCLUSION AND RECOMMENDATIONS

5.1 Conclusion

Library provides ability for researchers to easily get resources and information needed and facilitate them to have an opened mind. A library can appear in different types such as academic, private and public and its size is defined depending to the number of items it contains that can be counted from hundred up to millions. As to have a big number of items in the library may bring a lot of challenges when it comes to the purpose of management and achievement of fixed goals and objectives of library. This has been a reason of developing RFID library management system in order to keep all library resources well managed, secured as well as granting a high level of accessibility. Barcode technology were most used to automated library transactions. However, it presents a lot of limitations that a led non-satisfaction of users, failure to meet library's objectives and goals, poor services as well as insecurity of items. Radio Frequency Identification based Library Management and anti-theft (RLMATS) has been developed and implemented to overcome existing challenges. It focused on the use of Ultra High Frequency (UHF) band which enable readers and tags to send and receive data at longer range compared to other frequencies bands. It will facilitate users borrowing and returning library items with the help of RFID enabled modules without more human intervention. It also allows librarians to auto generate reports in desired format and increase efficiency, accuracy and security of library items. Furthermore, the system was not developed to meet needs of only predefined institutions rather than each institution of East African region as well as outside the region. As part of future work, this study researchers to find a technology that could applied for page removal and replace videos recording. However, the CCTV camera and time stamped access of library books provided with this developed system, will help to have video records of all library operations and facilitate to detect the actioner of pages removal.

5.2 Recommendations

This study recommends the following:

(i) Library staffs are recommended to organize seminars for library users to have clear service orientation. Also, they are recommended to ensure that all used devices are switched on.

(ii) Librarians (admins) are required to check recorded video to ensure that RFID labels are not removed from the targeted items and identify the actor of page removal.

(iii) Super-admin is recommended to ensure the established rules of the library are well respected by tracking the library activities of both admins and users.

REFERENCES

Alexander, A. (2010). Review of Public Libraries, Archives and Museums: Trends in Collaboration and Cooperation. *Collaborative Librarianship*, *2*(2), 110–111.

Bamgbade, B. J., Akintola, B. A., Agbenu, D. O., Ayeni, C. O., Fagbami, O. O., & Abubakar, H. O. (2015). Comparative analysis and benefits of digital library over traditional library. *Comparative Analysis and Benefits of Digital Library over Traditional Library*, *24*(2015), 1–4.

Bitter-Rijpkema, M. E., Verjans, S., & Bruijnzeels, R. (2011). The Library School: Empowering the sustainable innovation capacity of new librarians. *Library Management*, *33*(1–2), 36–49.

Cabonero, D. A., & Dolendo, R. B. (2013). Cataloging and classification skills of library and information science practitioners in their workplaces: A case analysis. *Library Philosophy and Practice*, *2013*(8), 1–38.

Čapligins, O., & Ermuiža, A. (2016). *MySQL Database Management System Forks Comparison and Usage*. *2*(2), 2–56.

Chanda, D. A. (2020). Barcode Technology and its Application in Libraries. *SSRN Electronic Journal*, *2*(7), 1–15.

David-West, B., & Angrey, C. (2018). Cataloguing and Classification Skills and Information Dissemination in Libraries. *Journal of Educational Research and Reviews*, *6*(7), 94–97.

Dhanalakshmi, M., & Mamatha, U. (2009). RFID Based Library Management System. *Proceedings of ASCNT 2009, CDAC, Noida, India*, *2*(1), 227–234.

Edwards, E., & Orukpe, P. (2014). Development of a RFID Based Library Management System and User Access Control. *Nigerian Journal of Technology*, *33*(4), 574.

Gilbert-Rolfe, C. (2017). Radio-Frequency identification. In *Digital Identity Management: Technological, Business and Social Implications 10*(2), 63–71.

Green, R. A. (2007). Library management: A case study approach. In *Library Management: A Case Study Approach*, *1*(1).

Grover, P., & Ahuja, A. (2010). Radio Frequency Identification Based Library Management System. *International Journal of Advanced Computer Science and Applications*, *1*(1), 41–

45.

Hamid, S. B. A., Diyana Rosli, A., Ismail, W., & Rosli, A. Z. (2012). Design and implementation of RFID-based anti-theft system. *Proceedings - 2012 IEEE International Conference on Control System, Computing and Engineering, ICCSCE 2012*, *3*(11), 452–457.

Hassan, A., & Ruchi, S. (2018). Barcodes Technology. *International Journal of Engineering Research & Technology*, *6*(2018), 1–2.

Isebe, I. E. (2014). Cause and effects of theft and mutilation of information materials in academic library services in delta state. *Cause and Effects of Theft and Mutilation of Information Materials in Academic Library Services in Delta State*, *4(10)*, 76-82.

Kadari, C., & Prasad, C. G. (2011). Implementation of Library Management System with RFID Technology. *International Journal of Advanced Research in Computer Science*, *2*(2), 228–235.

Kaur, M., Sandhu, M., Mohan, N., & Sandhu, P. S. (2011). RFID Technology Principles, Advantages, Limitations & Its Applications. *International Journal of Computer and Electrical Engineering*, *3*(1), 151–157.

Koneru, I. (2004). RFID Technology: A Revolution in Library Management. *Library*, *1*(3), 11–13.

Makhija, D., & Chugan, P. K. (2016). RFID Based Library Management System: The Benefits and Challenges. *Nineteenth International Conference on Management NICOM*, *1*(1), 219–231.

Mansfield, D. L. A. (2009). Reducing Book Theft at University Libraries. *Library and Information Research*, *33*(103), 10–15.

Ng, V., Weng, S., Muhammad, W., Bin, A., Mohd, W., & Amri, H. (2020). *Functionality and Features of Library Managemen System' s*. *July*, 1–6.

Nisha, F. (2018). Implementation of RFID technology at defence science library, DESIDOC: A case study. *DESIDOC Journal of Library and Information Technology*, *38*(1), 27–33.

OECD. (2008). Radio-Frequency Identification (RFID): A Focus on Information Security and Privacy. *IDEAS Working Paper Series from RePEc*, *138*, 10–23.

Saleem, H. (2012). Review of Various Aspects of Radio Frequency IDentification (RFID) Technology. *IOSR Journal of Computer Engineering*, *8*(1), 01–06.

Satrusallya, S., & Wunnava, A. (2019). RFID technology based library management system. *International Journal of Innovative Technology and Exploring Engineering*, *8*(11), 937–941.

Scott, S. H. (1984). *The Problem of Theft in Libraries and Strategies for Prevention and Response*.

Singh, G., & Sharma, M. (2015). Barcode technology and its application in libraries and Information centers. *International Journal of Next Generation Library and Technologies*, *1*(1), 1–8.

Singh, M. (2014). A snapshot of traditional library to modern library using bar code technology: An experience of central library GNDEC, Ludhiana. *Journal of Advances in Library and Information Science*, *3*(2), 146–149.

Smith, R. G., Menalled, F. D., & Robertson, G. P. (2007). Temporal yield variability under conventional and alternative management systems. *Agronomy Journal*, *99*(6), 1629–1634.

Taherdoost, H. (2016). Sampling Methods in Research Methodology; How to Choose a Sampling Technique for Research Hamed Taherdoost To cite this version: HAL Id: hal-02546796 Sampling Methods in Research Methodology; How to Choose a Sampling Technique for. *International Journal of Academic Research in Management*, *5*(2), 18–27.

Thiruvengadam, S., & Gokulakrishnan, S. (2020). Library Management System using RFID. *International Journal of Computer Applications*, *175*(10), 31–33.

Tosin, A. T. (2015). *Library Management System By Being a Project Report Submitted To the Department of Computer Science, Faculty of Science, Federal University Oye Ekiti, Ekiti State, Nigeria in Partial Fulfilment of the Requirement for the Award of Bachelor of Science*. 22–37.

Tripathi, A. (2012). Online Library Management System. *IOSR Journal of Engineering*, *2*(2), 180–186.

Urhiewhu, L. O., Emojorho, D., & Omah, J. E. (2018). Security Measures Adopted To Prevent Theft of Library Resources in Selected Academic Libraries. *International Journal of Library and Information Science Studies*, *4*(1), 1–10.

Vijayagowri, S., & Kousalya, B. (2016). Inteligent Library Mamagement System Using GSM and RFID. *International Journal of Research in Computer Applications and Robotics*, *4*(6), 33.

Waller, D. (2013). Current Advantages and Disadvantages of Using E-Textbooks in Texas Higher Education. *FOCUS on Colleges, Universities & Schools*, *7*(1), 1–6.

Yuan, Y., & Yu, D. (2012). UHF RFID shelf solution with cascaded reader antenna and positioning capability. *2012 IEEE International Conference on RFID, RFID 2012*, *2*(1), 149–156.

APPENDICES

Appendix 1: Questionnaire for Library Management System

Session A: Demography of Responses

1. What is your gender?

   - ⬭ Male
   - ⬭ Female

2. What is your age

   - ⬭ Under 18
   - ⬭ 18-30
   - ⬭ 31- 40
   - ⬭ 41-60
   - ⬭ 60+

3. What is the highest level of education did you complete?

   - ⬭ Secondary
   - ⬭ bachelor
   - ⬭ masters,
   - ⬭ PhD
   - ⬭ Other

Session B: Responses about Use and Services of Library

4. Does your institution/university have a library

   - ⬭ Yes
   - ⬭ No

5. How often do you access the internet?

- ⬭ Once a month
- ⬭ Once a week
- ⬭ Several times a week
- ⬭ Every day
- ⬭ never

6. What kind of devices do you use to access the internet?

- ⬭ Desktop
- ⬭ laptop
- ⬭ smartphone
- ⬭ tablet

7. Approximately, how often do you visit your library

- ⬭ Daily
- ⬭ Once a week
- ⬭ Several times a week
- ⬭ Once in month
- ⬭ Several times a month
- ⬭ Never

8. What type of materials do you mainly read when you visit your library? Check all apply

- ⬭ Bools
- ⬭ Newspaper
- ⬭ Journals
- ⬭ Thesis
- ⬭ Electronic references/

- Reports
- CD- OR DVD
- Others, specify

9. Which way do you use for finding the targeted library item?
   - Hardcopy catalogue/manual way
   - Online catalogue

10. Are the resources of your library accessible via internet?
    - Yes
    - No

11. Did you attend a workshop organized by the library of your institution?
    - Yes
    - No

12. What type of library management system does your library use?
    - Manual system
    - Computerized

13. If computerized system, what kind of technology?
    - Barcoding
    - QR
    - RFID
    - Other(specify)……

14. How much time it takes, when you want to borrow an item?
    - Equal or less than 5 min
    - 10 min
    - 15min

- ⬭ More than 15 min

15. Did you ever find a book with missing pages in your library (pages have been removed)?

- ⬭ Yes
- ⬭ No

16. What was the reason for your visit to the library? (Select all that apply)

- ⬭ Find a book or magazine
- ⬭ For class instruction
- ⬭ Get help with assignment
- ⬭ For self-study
- ⬭ Use computers in the library
- ⬭ Group study
- ⬭ Find internet connectivity
- ⬭ Use audiovisual equipment
- ⬭ Other (please specify) ……

17. what kind of security does your library use to prevent the theft of library items?

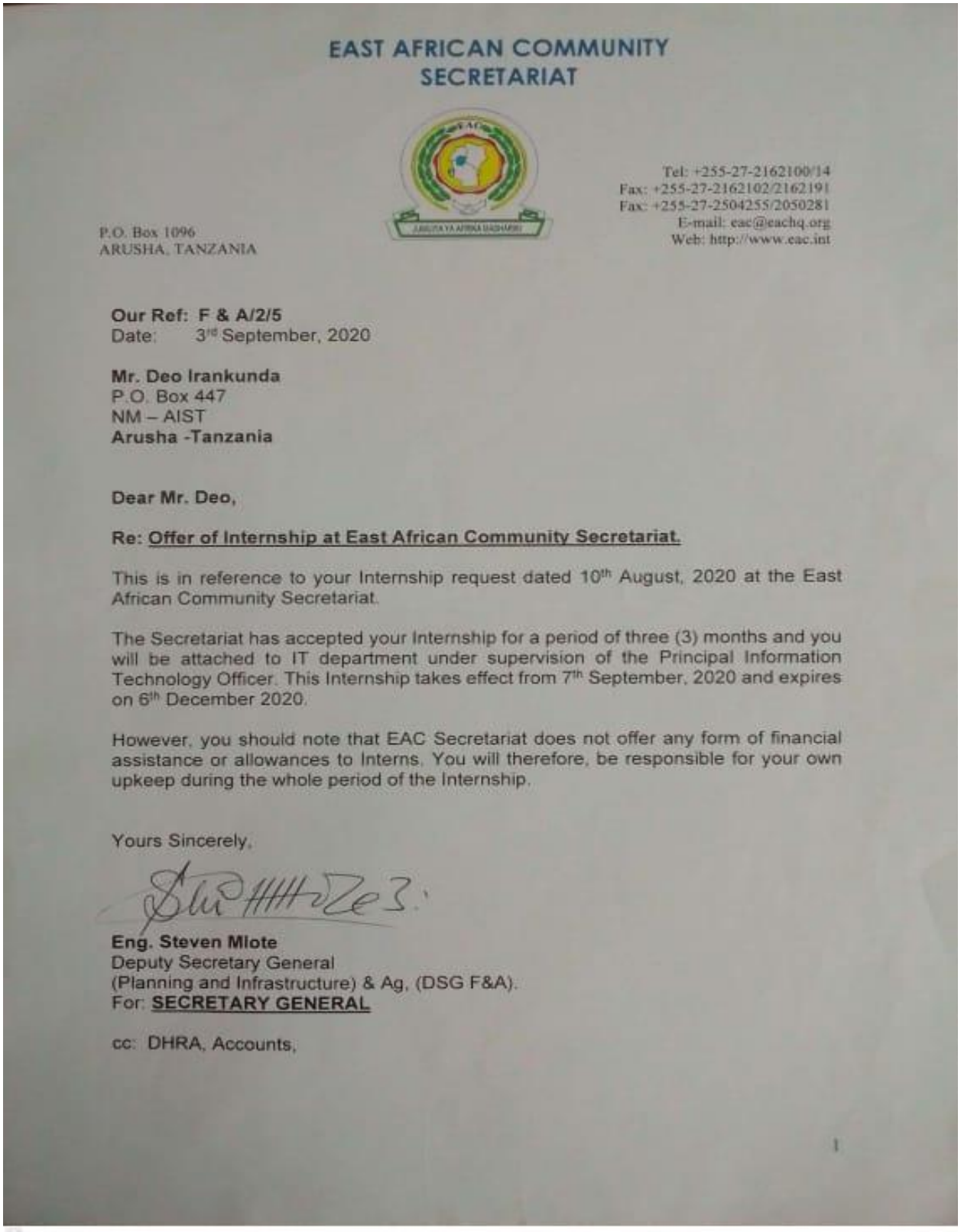
- ⬭ User's bags checking at the exit of library.
- ⬭ It is strictly forbidden to enter with a handbag
- ⬭ each user is required to sign in the library book
- ⬭ Surveillance camera
- ⬭ Guards are standing at the entrance and exit
- ⬭ Using an alarming system at the library exit
- ⬭ Librarians and guards make circulations in the library when users are inside
- ⬭ To enter by using biometric technology
- ⬭ Other …….

Session C: Satisfaction of Library Users

Indicate your level of satisfaction concerning the resources by completing the following statements:

Statements	**Strongly Agree**	**Agree**	**Neutral**	**Disagree**	**Strongly disagree**
Resources are appropriate for my course needs					
Resources are current and relevant					
Resources are easy to find					
Borrowing resources policies and procedures are clearly stated					
I usually find the needed resources					
Recommendations for new or different resources are listed by the library staff					
The librarians provide a good assistance					
I am satisfied of your library services					
Internet connection of my library is very faster					

Appendix 2: Internship Offer Letter



EAST AFRICAN COMMUNITY
SECRETARIAT

P.O. Box 1096
ARUSHA, TANZANIA

Tel: +255-27-2162100/14
Fax: +255-27-2162102/2162191
Fax: +255-27-2504255/2050281
E-mail: eac@eachq.org
Web: http://www.eac.int

Our Ref: F & A/2/5
Date: 3rd September, 2020

Mr. Deo Irankunda
P.O. Box 447
NM – AIST
Arusha -Tanzania

Dear Mr. Deo,

Re: Offer of Internship at East African Community Secretariat.

This is in reference to your Internship request dated 10th August, 2020 at the East African Community Secretariat.

The Secretariat has accepted your Internship for a period of three (3) months and you will be attached to IT department under supervision of the Principal Information Technology Officer. This Internship takes effect from 7th September, 2020 and expires on 6th December 2020.

However, you should note that EAC Secretariat does not offer any form of financial assistance or allowances to Interns. You will therefore, be responsible for your own upkeep during the whole period of the Internship.

Yours Sincerely,

Eng. Steven Mlote
Deputy Secretary General
(Planning and Infrastructure) & Ag, (DSG F&A).
For: **SECRETARY GENERAL**

cc: DHRA, Accounts,

1

Appendix 3: Sample of Codes Used for Library Web Development

Home page codes

```
<!DOCTYPE html>
<html lang="en">
<head>
 <meta charset="utf-8">
 <meta content="width=device-width, initial-scale=1.0" name="viewport">

 <title>Information Resources Centre</title>
 <meta content="" name="description">
 <meta content="" name="keywords">
 <!-- ======= Header ======= -->
 <header id="header" class="fixed-top">
  <div class="container d-flex align-items-center justify-content-between">

   <h1 class="logo"><img src="images/eaclogo.jpg">EAC</a></h1>
   <!-- Uncomment below if you prefer to use an image logo -->
   <!-- <a href="index.html" class="logo"><img src="assets/img/logo.png" alt="" class="img-fluid"></a>-->
   <nav id="navbar" class="navbar">

  <ul>
   <li><a class="nav-link scrollto active" href="#hero">Home</a></li>
   <li><a class="nav-link scrollto" href="http://localhost/eac1/about">About</a></li>
   <li><a class="nav-link scrollto" href="http://localhost/eac1/services">Services</a></li>
   <li><a class="nav-link scrollto" href="http://localhost/eac1/team">Team</a></li>
   <li><a class="nav-link scrollto" href="#contact">Contact</a></li>
   <li><a class="getstarted scrollto" href="http://localhost/eac1/loginpage">Get Started</a></li>
  </ul>
```

```
      <i class="bi bi-list mobile-nav-toggle"></i>
    </nav><!-- .navbar -->
  </div>
</header><!-- End Header -->
<!-- ======= Hero Section ======= -->
<section id="hero" class="d-flex align-items-center">
  <div class="img-fluid d-flex flex-column align-items-center justify-content-center" data-aos="fade-up">
    <p>. </p>
    <h1>Welcome to Information Resources Centre of EAC</h1>
    <img src="images/library4.jpg" class="img-fluid hero-img" alt="" data-aos="zoom-in" data-aos-delay="150">
  </div>

</section><!-- End Hero -->
<main id="main">
  <!-- ======= About Section ======= -->
  <section id="about" class="about">
    <div class="container">
      <div class="row no-gutters">
        <div class="content col-xl-5 d-flex align-items-stretch" data-aos="fade-right">
          <div class="content">
            <h3>The EAC Information Resource Centre</h3>
            <p>
              The EAC Information Resource Centre plays a central role as a provider of information and knowledge to the EAC Organs and Institutions,
            </p>
            <div class="col-md-12 icon-box" data-aos="fade-up" data-aos-delay="100">
              <i class="bx bx-receipt"></i>
              <h4>Vision</h4>
```

```
            <p>A one stop centre for information on the East African Community regional integration journey </p>

          </div>

        </div>

      </div>

      <div class="col-xl-7 d-flex align-items-stretch" data-aos="fade-left">

        <div class="icon-boxes d-flex flex-column justify-content-center">

          <div class="row">

            <div class="col-md-6 icon-box" data-aos="fade-up" data-aos-delay="100">

              <i class="bx bx-receipt"></i>

              <h4>Mission</h4>

              <p>TTo develop a specialized centre of information and knowledge on the East African Community regional integration journey </p>

            </div>

            <div class="col-md-6 icon-box" data-aos="fade-up" data-aos-delay="200">

              <i class="bx bx-cube-alt"></i>


              <p>The main objective of the Information Resource Centre is to avail relevant information and knowledge in support of the Organs of the Community in fulfilling their mandate </p>

            </div>

            <div class="col-md-6 icon-box" data-aos="fade-up" data-aos-delay="300">

              <i class="bx bx-images"></i>

              <h4>Other Objectives</h4>

              <p>To specialize in the collection, organization, and dissemination of analyzed information in areas of cooperation</p>

              <p> To collaborate with other information centres in EAC institutions/ Partner States to develop local content of the EAC region</p>

            </div>

            <div class="col-md-6 icon-box" data-aos="fade-up" data-aos-delay="400">

              <i class="bx bx-shield"></i>
```

```
<h4>The Focus of IRC</h4>

            <p>The EAC Information Resource Centre manages and maintains an electronic Library (e-Library).

          </div>

            <button> <a href="http://elibrary.eac.int/about/history/" class="about-btn"> Read more "Background On The Establishment Of EAC Information Resource Centre (IRC)" <i class="bx bx-chevron-right"></i></a> </button>

          </div>

        </div>

         </div>

        </div><!-- End .content-->

       </div>

      </div>
```

Add user codes

```
<div class="modal fade" id="modal-xl">

     <div class="modal-dialog modal-xl">

      <div class="modal-content">

       <div class="modal-header">

        <h4 class="modal-title">ADD A NEW USER</h4>

        <button type="button" class="close" data-dismiss="modal" aria-label="Close">

         <span aria-hidden="true">&times;</span>

        </button>

       </div>

       <form method="post" enctype="multipart/form-data" id="user_form" >

       <div class="modal-body">

        <div class="row">

         <div class="col-lg-6">

          <div class="form-group">

           <label for="name">Full Name</label>
```

```
            <input type="text" class="form-control" id="name" placeholder="Full Name"
name="name">
            <span id="name_error" class="text-danger"></span>
          </div>
            <div class="form-group">
             <label>Gender:</label>
             <select class="custom-select" id="gender" name="gender" >
              <option value="">Select Gender</option>
              <option value="M">Male</option>
              <option value="F">Female</option>
             </select>
             <span id="gender_error" class="text-danger"></span>
            </div>
            <div class="form-group">
          <label>Phone number:</label>

          <div class="input-group">
            <div class="input-group-prepend">
             <span class="input-group-text"><i class="fas fa-phone"></i></span>
            </div>
                        <div class="form-group">
            <label for="email">Email address</label>
            <input type="email" class="form-control" id="emal" placeholder="Enter email"
name="email">
            <span id="email_error" class="text-danger"></span>
          </div>
          <!-- <div class="form-group">
            <label for="Rfid_user_ID">Rfid-User</label>
            <input type="text" class="form-control" id="Rfid_user_ID" placeholder="Enter
Rfid-User" name="Rfid_user_ID">
```

```
<span id="rfidUser_error" class="text-danger"></span>
            </div> -->
              <div class="form-group">
              <label for="Rfid_user_ID">Rfid-User</label>
            <div class="row">
              <div class="col-lg-8">


              <input type="text" class="form-control" id="Rfid_user_ID" placeholder="Enter
Rfid-User" name="Rfid_user_ID">
              <span id="rfidUser_error" class="text-danger"></span>
            </div>
                              <div class="col-lg-4">
              <!-- Button trigger modal -->
              <button type="button" class="btn btn-primary" data-toggle="modal" data-
target="#exampleModal">
                ScanRFID
              </button>


                 </div>
             <div class="col-lg-6">
              <div class="form-group">
              <label>Date masks:</label>
              <div class="input-group">
                <div class="input-group-prepend">
                  <span class="input-group-text"><i class="far fa-calendar-alt"></i></span>
                </div>
                <input type="Date" class="form-control" data-inputmask-alias="datetime" data-
 inputmask-inputformat="dd/mm/yyyy" id="Date_Of_Birth" name="Date_Of_Birth" data-
 mask>
                <span id="date_error" class="text-danger"></span>
              </div>
```

```
<!-- /.input group -->
            </div>
             <div class="form-group">
                <label>Department :</label>
                <select class="custom-select" name="department" id="department">
                 <option value="">Select department</option>
                 <option value="Department 1">Department 1</option>
                 <option value="Department 2">Department 2</option>
                 <option value="Department 3">Department 3</option>
                 <option value="Department 4">Department 4</option>
                </select>
                <span id="departement_error" class="text-danger"></span>
               </div>
               <div class="form-group">
              <label for="exampleInputFile">File input</label>
              <div class="input-group">


<div class="custom-file">
                  <input type="file" class="custom-file-input" id="exampleInputFile"
name="photo">
                  <label class="custom-file-label" for="exampleInputFile">Choose file</label>
                </div>
```

Book management codes

```
<div class="col-lg-12">
        <div class="card">
        <div class="card-header">
          <h3 class="card-title">BOOKS MANAGEMENT</h3>
        </div>
        <!-- /.card-header -->
        <div class="card-body">
```

```
          <div class="table-responsive">
          <table id="book_table" class="table table-bordered table-striped" style="font-size:
0.85em;">
            <thead>
            <tr>
              <th>Book Title</th>
              <th>Author</th>
              <th>Category</th>
              <th>Publisher Name</th>
              <th>Nbr copies</th>
              <th>Date added</th>
              <th>Action</th>
            </tr>
            </thead>
           <tbody>
           </table>
          </div>


</div>
          <!-- /.card-body -->
        </div>
      </div>
<div class="modal fade" id="modal-xl_addNewBook">
      <div class="modal-dialog modal-xl">
        <div class="modal-content">
          <div class="modal-header">
            <h4 class="modal-titlebook">Add new Book</h4>
            <button type="button" class="close" data-dismiss="modal" aria-label="Close">
              <span aria-hidden="true">&times;</span>
            </button>
```

```
</div>
<form method="post" enctype="multipart/form-data" id="book_form">
   <div class="modal-body">
 <div class="row">
            <div class="col-lg-6">
             <div class="form-group">
              <label for="bookTitle">Book bookitle</label>
              <input type="text" class="form-control" id="bookTitle" name="bookTitle"
placeholder="Book Author">
            <span id="bookTitle_error" class="text-danger"></span>
            </div>
            <div class="form-group">
             <label for="bookAuthor">Book Author</label>
              <input type="text" class="form-control" id="bookAuthor" name="bookAuthor"
placeholder="Book Author">
            <span id="bookAuthor_error" class="text-danger"></span>
            </div>

<div class="form-group">
            <label for="publisherName">Publisher name</label>
            <input type="text" class="form-control" id="publisherName"
name="publisherName" placeholder="Publisher name">
            <span id="publisherName_error" class="text-danger"></span>
           </div>
           <div class="form-group">
            <label for="publisherYear">Publication year</label>
            <input type="year" class="form-control" id="publisherYear" name="publisherYear"
placeholder="Publication year">
            <span id="publisherYear_error" class="text-danger"></span>
           </div>
           <div class="form-group">
```

Codes for Book borrow form

```
<div class="modal fade" id="modal-xl">
      <div class="modal-dialog modal-xl">
       <div class="modal-content">
        <div class="modal-header">
         <h4 class="modal-title"> BORROW A BOOK</h4>
         <button type="button" class="close" data-dismiss="modal" aria-label="Close">
          <span aria-hidden="true">&times;</span>
         </button>
        </div>
        <form method="post" enctype="multipart/form-data" id="user_form" >
        <div class="modal-body">
         <div class="row">
          <div class="col-lg-6">
           <div class="form-group">
            <label for="name">Full Name</label>
            <input type="text" class="form-control" id="name" placeholder="Full Name"
name="name">

<div class="form-group">
            <label>Phone number:</label>


            <div class="input-group">
             <div class="input-group-prepend">
              <span class="input-group-text"><i class="fas fa-phone"></i></span>
             </div>
             <input type="text" class="form-control"
                  data-inputmask="'mask': ['999-999-9999 [x99999]', '+099 99 99 9999[9]-
9999']" name="phone" id="phone" data-mask>
```

```
                    <span id="phone_error" class="text-danger"></span>
                  </div>
                  <!-- /.input group -->
                 </div>
                   <div class="form-group">
                   <label for="email">Email address</label>
                   <input type="email" class="form-control" id="emal" placeholder="Get email"
  name="email">
                   <span id="email_error" class="text-danger"></span>
                  </div>
  <div class="col-lg-6">
                  <div class="form-group">
                   <label for="Home_Address">Book name</label>
                   <input type="text" class="form-control" id="Home_Address" placeholder="Book
  Title" name="Home_Address">
                   <span id="address_error" class="text-danger"></span>
                  </div>


</div>
                   <div class="form-group">
                 <label for="Home_Address"> Author</label>
                 <input type="text" class="form-control" id="Home_Address" placeholder="Author
name" name="Home_Address">
                 <span id="address_error" class="text-danger"></span>
                </div>
                  <div class="form-group">
                 <label for="Home_Address">Book Id</label>
                 <input type="text" class="form-control" id="Home_Address" placeholder="Book
Id" name="Home_Address">
                 <span id="address_error" class="text-danger"></span>
                </div>
```

```
<div class="form-group">
<label for="Rfid_user_ID">Rfid-Book</label>
<div class="row">
<div class="col-lg-8">
<input type="text" class="form-control" id="Rfid_user_ID" placeholder="Enter Rfid-User" name="Rfid_user_ID">
<span id="rfidUser_error" class="text-danger"></span>
</div>
<div class="col-lg-4">
<!-- Button trigger modal -->
<button type="button" class="btn btn-primary" data-toggle="modal" data-target="#exampleModal">
Get RFID Book
</button>
</div>
</div>
</div>
```

RESEARCH OUTPUTS

Appendix 4: Published Article

International Journal of
Advances in Scientific Research and Engineering (ijasre)

E-ISSN : 2454-8006

DOI: 10.31695/IJASRE.2021.34016

Volume 7, Issue 5
May - 2021

Development of the RFID Based Library Management and Anti-Theft System: A Case of East African Community (EAC) Region

Deo Irankunda[1], Ramadhani Sinde[2], Neema Mduma[3], Mussa Ally. Dida[4]

Scholar[1], Lecturer[2,3] Senior Lecturer[4]

School of Computational and Communication Sciences and Engineering

Nelson Mandela African Institution of Science and technology

Arusha-Tanzania

ABSTRACT

Radio Frequency Identification (RFID) Systems are becoming very useful in our daily life due to its advantages such as reduction of human error, theft prevention, time consuming reduction, the auto identification of targeted objects, business processes automation etc. RFID systems has been applied in library to manage items and library operations. Different approaches have been adopted in library management system in the East African region unfortunately some challenges including theft, pages removal, non-customer satisfaction, high cost of used system etc. are still persisting. To address these challenges, an RFID based library management and anti-theft system has been developed to East African Community (EAC) library. It focused on the use of Ultra High Frequency (UHF) band which enable readers and tags to transmit and receive data at long range. The developed system facilitates users to borrow and return library items using RFID modules and enable librarians to monitor, record library activities and prevent no issued item to cross the library entrance or exit.

Keywords: RFID, Library Management System, Anti-Theft, Ultra High Frequency.

1. INTRODUCTION

A library is a curated collection of sources of information and similar resources, selected by experts and made accessible to a defined community for borrowing, reading, often a quiet environment for conductive study [1]. It is a place where people can get information in a different format found in various materials such as books, newspapers, manuscripts, films, maps, documents, CDs, cassettes, prints, e-books, audiobooks etc. A library is an important part of the academic sector as well as professional sectors [2]. It can appear in different types such as academic, private, public etc. and its size depend on the number of items it contains [3]. Having a big number of items in the library may bring a lot of challenges when comes to the purpose of management and achievement of fixed goals and objectives of library. According to Padmaj 2019, a library to accomplish its objectives and goals needs efficiency in its operations, which lies on how the books are arranged and how easily users can get books of their choice, issuing and return borrowed items[4]. Koneru, 2004 defined library management as the action of keeping an eyes on library department functions and maintain all records of the library in such a way the library stays in an operative manner and keeps the constant track of all library items in store. According to Smith et al., 2007, library management is the system developed for handling basis functions of a library, providing a complete administration solution of a library's technical function and services to the defined community[6]. It includes areas such as books circulation or reviewing, classification of materials, catalogue management, patron management, online access, search facility etc. [7]. Furthermore, the presence of Information and Communication Technology (ICT) has become a concern of libraries and institutions around the world and changed their working way. According to M. Singh, 2014, a library assistant at Guru Nanak Dev Engineering College, Ludhiana (GNDEC), ICT has brought a remarked change in different prospectus of human endeavor. As libraries remain the primary source of information for thousands of people, their managements have been taken as a key features of many organizations including EAC which need to be improved and reinforced. On handling library management, several technologies such as barcoding, RFID, software based, can be used in the prospectus to automate activities in general. Despite works which have been done, libraries around the world are still experiencing several challenges including theft, pages removal, high cost etc. followed by addition of improvised budget for item replacement and maintenance. Therefore, this study aimed to develop RFID based library management and anti-theft system to

provide features of maximization of time, preventing theft and keeping track of library items using the radio waves. The system automates the book handling process including checkout, check-in, shelf management, item borrowing and returning without requiring more of human interaction and generate alerts in case of non-issued items across the exit doors of library.

1.1. RFID in the Library

A radio frequency identification is a computing technique based on the use of radio waves for transmitting and receiving data between a reader and movable item to identify, categorize and track wirelessly [10]. It facilitates the library transactions with the help of RFID modules without human (manual) typing, provides a monitoring module and increase security. Through this technology, books or others items are easily located in case of misplacement. The method is fast, secure and provides a unique identification and backend integration. RFID system comprises of three main components which interact with computer system:

- RFID readers
- RFID tags/labels
- Antenna

An RFID reader and transponders are designed with a microchip inside to deals with signal processing and antenna for sending and receiving data via radio waves. Transponders exists in two types which can either be actives or passives with non-battery inside and powered by the radios waves from the RIFD reader [11] [12].

2. RELATED WORKS

Several researches have been done and come up with different computerized methods to be used for overcoming limitations caused by Manual Library Management System (MLMS). The barcode technology is one of computerized system adopted in many libraries which involves the use of software and hardware. In 2005, Singh & Sharma designed a system-based barcode identification with the aim of reducing time consuming and overcoming others challenges found in manual system[14]. However, the system exposed to a lot of limitations: requires a physical sight to scan a barcode which involve the human intervention unable to read more than one barcode at once and its readability can be affected by moisture, dirty, absorption, packaging etc. Furthermore, Hamid,2012 described that there are no perfect system for actual tracking of books in the library and display their location [15]. For that reason, the system was developed based on UHF readers to read tag at high distance compare to other frequencies. UHF RFID tag was placed at the shelves and big number of RFID reader was used. Similar system has been developed to pilot a university library[16]. The study used Graphical User Interface (GUI) to support all necessary library functionalities and user needs. Shelf antennas that were optimized with a target of maximize tag readability as well as minimizing the pollution of electromagnetic in the vicinity cabinet were used [17]. However, the systems were very cost effective due to requirements such as confined reading area and positioning ability to know where the label is along to the shelf. [18] observed that books and pages are disappearing at University of Lincoln due to bad behavior of employees and students. Regular library checks in, security gates and maintenance to avoid failures was recommended. According to Alexander, bag searching acts was a deterrent and heightens security awareness[19]. However, this approach didn't succeed to stop the theft. Therefore, solutions that incorporate technologies such as CCTV camera were integrated and brought more advantages.

3. MATERIALS AND METHODS

3.1.Case study

The study was carried out in East African region, particularly at East Africa Community secretariat, in the Information Resource Centre (IRC) department located in Arusha-Tanzania and in the Vivian A. DAKE Memorial library of Hope Africa University located in Bujumbura-Burundi.

3.2. Data Collection Methods

On carrying this study, data was gathered from library staff and other users to determine challenges and needs for library management. The collected data were classified into two categories such as primary and secondary data. Primary data are those which were collected afresh and for the first time and thus happen in the original form, not published yet and more reliable while secondary data were collected from the published materials.

3.2.1. Primary Data

The primary data were obtained from librarians of Information Resource Centre of EAC and from library admin and students from Hope Africa University (HAU). Discussion, observation, interviews, questionnaire and face to face conversation were methods used to obtain all needed information. Discussion was conducted to assess the existing system and determine their weakness and

DOI: 10.31695/IJASRE.2021.34016

strength. Observation was conducted to both libraries to observe how services were delivered to library's patrons while interview was conducted to librarians to investigate scenario which libraries were going through in embarking an automation library. Furthermore, questionnaire was conducted to librarians and users to identify the level of users' satisfaction and challenges met when they visited library. Also, face to face conversation method was used when conducting interview with library admin to identity and agree on requirements of the developed system. Google form was used as the technical tool to capture data from respondents.

3.2.2. Secondary Data

In order to grasp relevant information of the developed system documentation method was used. Books, reports, various publications, internet articles etc. were analyzed to identity what has been done by other researchers together with observations, recommendations and solutions proposed.

3.2.3. Data analysis

Data processing was conducted in prior of analysis in order to make it consistent. Open refine and google sheets are the tools used to process data, reshapes and intelligently batch edit. Tables were used for quantitative data analysis due to the influence of interactive features and ability of proving efficient results.

3.3.Description of the developed system

The developed system based on UHF RFID where the RFID labels was embedded on library items and user was assigned a smart card. It comprises two main parts: development of software and hardware integrations. The first part provides diverse features via interfaces: user, admins(librarians) and super-admin to help users to interact with the system and the second focuses on hardware integration. In addition of RFID devices, the CCTV devices were used to enable to all activities within library to be recorded. In engineering, data flow diagram is tools that illustrates the flow of data through the interaction of different entities of the system. It is a graphical depiction of the flow of information that are applied to data movement from the input to output. Figure 1 show how used devices are interconnected and figure 2 depicts the interactions between LMS and external entities.

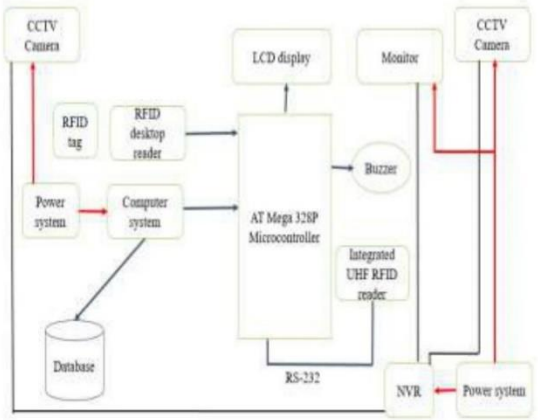


Figure 1: System block diagram

DOI: 10.31695/IJASRE.2021.34016

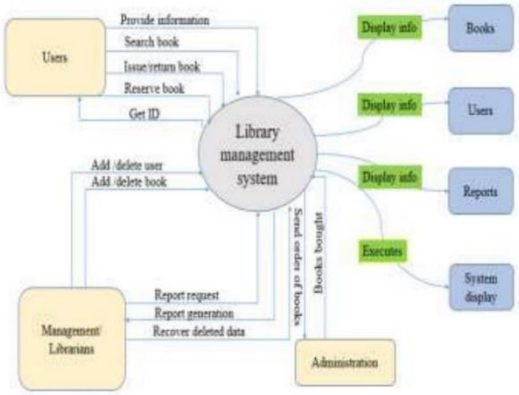


Figure 2: Context diagram

3.4.System Requirements

3.4.1. Software Requirements and Tools Used

During development of this system, windows operating system version 10 was used. The selection was based due to the fact that it is stable, supports more features and user friendless. Others tools used to develop the library web based focused on front end such Cascading Style Sheets (CSS), Hyper Text Markup Language (HTML) and Java script, back end: Code Igniter, MySQL, XAMPP server and sublime programming editor.

3.4.2. Hardware tools used and their specifications

ATMEGA328P Microcontroller is high performance, low power controller from Microchip, designed with 8bit microcontroller based on AVR RISC architecture. It is mostly used in low powered and low cost projects and autonomous where microcontroller is required. ATMEGA 382P has 28 pins chip in total, analog, digitals, power and ground pins as shown in the figure 7 below and operate at 0V to 5V (figure 3).

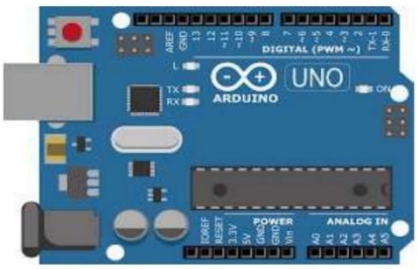


Figure 3: AT Mega 328P Microcontroller

RFID tag for users: RFID Tag is a kind of transceiver device used to exchange data with radio frequency identification reader through radio frequency waves. It has two main parts whose Integrated Circuit (IC) used for data processing and storing as well as modulating and demodulating radio waves received/sent and antenna as second part.

DOI: 10.31695/IJASRE.2021.34016

Figure 4: RFID Tag for users

Buzzer: Buzzer is a kind of voice device that converts audio model into sound signal. According to different design and application, it can produce music sound, flute sound, alarm sound, electric bell and other different sounds. A buzzer has 2 pins and a DC operating voltage of 5v.

Figure 6: Buzzer

LCD display: A liquid-crystal display is an electronic device that use liquid crystal to display data from inputs devices electronically optical modulated and used in most cases, as user interfaces of the system. LCD disposes 16 pins, operates at 5v DC voltage. A RC2004A is monochromatic 20x4 alphanumeric LCD able to display 20characters at each 4rows adopted to be used in this system.

Figure 7: LCD display

UHF RFID Integrated reader VI-83TF: A UHF RFID reader is a device using an Ultra-High Frequency band whose range is between 84OMHz and 960MHz. It has an extended read range compared to other LF, HF readers. It has features of STMicroelectronics STM Cortex-M3 core CPU processor with ultra-low power consumption and ultra-high performance which makes the reader program and interface run more stable and faster. It can use standard interfaces (TCP/IP, RS485, RS232, Wiegand interface) and optional (wireless WIFI, Bluetooth) with an operating DC voltage of 9-24V and temperature of -20ºC～+60ºC.

Figure 8: UHF RFID Integrated reader

UHF RFID Book archive tag LA-86C: RFID labels have a high security performance, a global unique code identification and widely used in libraries, database rooms and secrets archives [20]. UHF RFID book labels are compatible with EPC CLASS1 Gen 2 / ISO 18000-6C protocol, able to read and transmit data within a reading range of 0-5 meters depending on reader's performance and work with a temperature of -20°C~+50°C.

DOI: 10.31695/IJASRE.2021.34016

Figure 9: UHF RFID Book label

4. RESULTS

4.1.Demographics characteristics

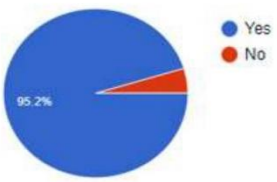
Assessment demographic of respondents in this study was very inevitable to assess attitude and prospective of library stakeholders through the use of Information and Communication Technology (ICT). This study examined gender, age, education level and experience of using internet and library. Table 3 below demonstrates the socio-demographic details of each category of respondents. The total number of 105 respondents were examined with number of male greater than number of female respondents. For the case of education level and age, the majority of respondents acquired bachelor degree with ages ranged from 18 to 40.

Table 2: Demographic characteristics of respondents

Demographic features		Respondents	Percentage %
Gender	male	62	59
	Female	43	41
	under 18	1	1
	18-30	57	54.3
Ages	31-40	41	39
	41-60	6	5.7
	Above 60	0	0
	Secondary	6	5.7
Education	Bachelor	46	43.8
	Masters	36	34.3
	PhD	17	16.2

4.2.Existence of libraries and its use in EAC region

Figure 10 shows that 95.2% of academic's institution in the EAC region have libraries where students, lecturers and researches use to search information related to works. Figure 11 illustrated that 27.8% of respondents visited library several times a week while 2.6% of respondents visited library rarely. Users visit library for different purposes such find book, articles, magazines, doing a self-study etc.



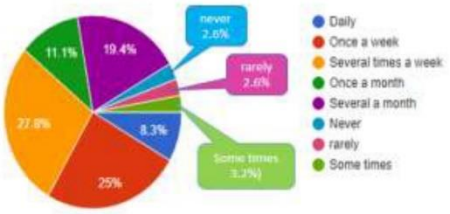


Figure 10: Existence of library in academic's institutions

Figure 11: Number of times of visiting library

4.3.Library management system used

A survey was also conducted to identify which libraries management system were mostly used in the region. The results showed that 61% of library were computerized which means the use of ICT technology has been integrated in library management and 39% were using manual methods. However, the data collected from respondents illustrates that libraries are using different computerized methods such as software (51.9 %) while Q-R technology is not mostly used (0%) (Table 3).

DOI: 10.31695/IJASRE.2021.34016

Table 3: Library management system used in EAC region

LMS		Respondents	Percentage %
Types	Computerized	64	61
	Manual	41	39
Technology used	in computerized		
	RFID	11	13.9
	Barcode	21	26.6
	Software	41	51.9
	Q-R	0	0

4.4. Internet usage and technological devices

A survey was also conducted to identify how internet were used in academic sector and which devices were mostly used. Results from the respondents showed that 99% of educated people accessed internet with different proportions of times. As shown in the figure 13, 43.8% accessed internet daily, 44.8% several times a week while 1% never accessed it. Figure 14 shows devices which were used to access internet, 81.9% access internet using laptop while 19% accessed using tablet.

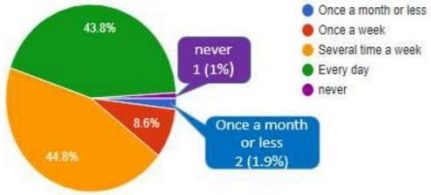


Figure 13: Number of times that internet is accessed

Figure 14: Devices used to access internet

4.6. Types of security used in existing system

To identify the level of library security, a survey was conducted and results showed that libraries used different security measures. 80.9% of libraries strictly forbid to enter in the library with a handbag while 0.9% revealed used alarming systems at the library exit (Table 4).

Table 4: Methods used to prevent loss of library items

Methods used	Respondents	%
User's bags checking at the exit of library	65	61.9
It is strictly forbidden to enter with a handbag	85	80.9
Each user is required to sign in the library book	41	39.04
Surveillance camera	22	20.9
Guards are standing at the entrance and exit	19	18.09
Using an alarming system at the library exit	1	0.9
Librarians and guards make circulations in the library when users are inside	1	0.9
Using biometric technology to enter	12	11.4

4.7. Challenges in library

In order to understand challenges that facing libraries, the survey was conducted and results showed that pages removal and theft exist. 42.85% of respondents confirmed theft occurred several times a year while 15.23% denied. The results continued to show that 68.57% of respondents responded positively that books missed pages while 31.42% responded negatively pages (Table 5).

Table 5: Challenges founds in existing systems

Subject	Number of times	respondents	Percentage %
	Once a day	0	0
	Once a week	2	0.019

DOI: 10.31695/IJASRE.2021.34016

	Several times a week	4	0.38
Theft in library			
	Once a month	6	0.57
	Several times a month	7	0.66
	Once a year	25	23.80
	Several times a year	45	42.85
	Never	16	15.23
Book pages removed	Yes	72	68.57
	No	33	31.42
Times used	in borrowing process		
	Equal or less than 5 min	11	10.6
	10 min	42	40.4
	15 min	38	36.5
	More than 15 min	13	12.5

4.7.1 Problem of existing system

After observing existing library management systems both manual and computerized, the following problems were highlighted:

(i) Loss of data: In some of the systems, data are not centralized and they are kept in a book or peace of papers.
(ii) Time consuming: Time consuming tends to differ from manual to barcoding system. Manual system takes a lot of time in report generation and users cannot be tracked easily.
(iii) Error: Manual and barcoding system are exposed to human error.
(iv) Theft: Each year in many libraries around the world including libraries of East African region loss items.
(v) Page removing: The act of losing pages which contains important information.

4.8.RLMAS database implementation

The database of this system was developed and supported by MySQL database management and PHP scripts for user's web connectivity. Figure15 illustrates number of tables used to develop the web based of this system and associations in the application.

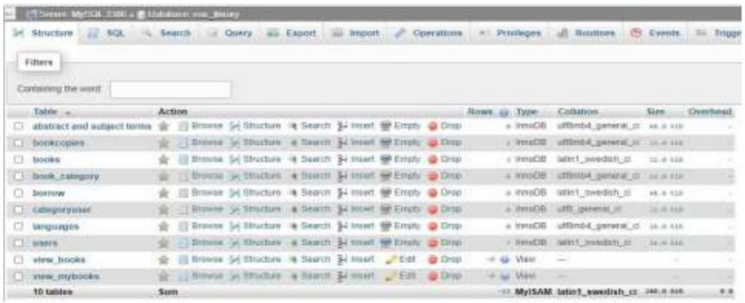


Figure 15: Database implementation

4.9. Input and Output design

The developed application is responsive for different ICT devices such as laptop, desktop, smartphone etc. The figures 16,17,18,19 and 20 show modules used to enable users and librarians to perform the desired tasks. The home page gave an overview of the system and presented a login panel where each category of users is required to enter credentials. Once login, users were directed to pages containing information depending to their categories.

Book borrow module

All registered users have rights to borrow book copies while original books are restricted. By clicking the borrow button, users are required to enter details by swapping tag on desktop reader then personal information such name, user ID and emails will be appeared in the form. Then, user continues with scanning the preferred book as shown in figure 20. However, the process of borrowing can be denied due to the following case:

DOI: 10.31695/IJASRE.2021.34016

(i) The allowed number of item to be borrowed has been exceeded (2 or 3 items are allowed but depending on library regulations).
(ii) Users didn't return the previous borrowed items.

To return borrowed item, borrowers is also required to use their tag ID then scan borrowed item. When users are not around library, the system gives ability to reserve a book in the interval of 48 hours.

Figure 16: Home and login page

Figure 17: User registration

Figure 18: Book registration

Figure 19: Book borrow

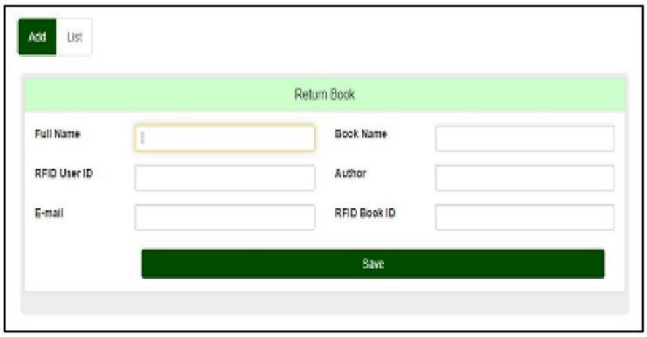


Figure 20: Book return

5. DISCUSSION

Many educational institutions in the EAC region dispose libraries which are highly visited by people of different range of studies with various purpose. They play significant role of supporting students, researchers and lecturers to find needed information. Many library management systems were implemented to solve problem and vulnerabilities of traditional and barcode system in

DOI: 10.31695/IJASRE.2021.34016

library unfortunately problems still appearing and affect libraries in different points [13]. To address this issue, a compatible system able to read hidden items even at big distance and generate alarm has to be developed and implemented. The measurement and identification of vulnerabilities in existing systems has been done first then collection of requirements of the new system. A radio frequency identification is a computing advanced technique able to transmit and receive data between a reader and movable item to identify, categorize and track wirelessly [10]. The previous study demonstrated that RFID even brought remarkable advantage, cannot be used for record and become incompatible when tags or labels have been removed on targeted objects reason why CCTV become more advantage. It could be a good pleasure for future work to find a system able to fight against this page removal.

6. CONCLUSION

Library provides ability for researchers to easily get resources and information needed and facilitate them to have an opened mind. This study aimed to develop a system for solving existing challenges by keeping all library resources well managed, secured as well as granting a high level of accessibility. The developed system 'RFID based Library Management and anti-Theft system" (RLMATS) focused on the use of Ultra High Frequency (UHF). It facilitated users to borrow and return library items with the help of RFID enabled modules without more human intervention. This system leads a significant time management in operation, enhances customer service and provides security of the library items by issuing an alert if non-issued item detected when user cross library entrance or exit. Furthermore, the system was not developed to meet needs of only institutions of East African region rather than outside the region.

REFERENCE

[1] M. Dhanalakshmi and U. Mamatha, "RFID Based Library Management System," *Proc. ASCNT 2009, CDAC, Noida, India*, vol. 2, no. 1, pp. 227–234, 2009.

[2] I. E. . Isebe, "Cause and effects of theft and mutilation of information materials in academic library services in delta state," *Cause Eff. Th. mutilation Inf. Mater. Acad. Libr. Serv. delta state*, vol. 4(10), pp. 76-82., 2014.

[3] A. T. Tosin, "Library Management System By Being a Project Report Submitted To the Department of Computer Science , Faculty of Science , Federal University Oye Ekiti , Ekiti State , Nigeria in Partial Fulfilment of the Requirement for the Award of Bachelor of Science (," p. 70, 2015, [Online]. Available: https://www.academia.edu/33632232/LIBRARY_MANAGEMENT_SYSTEM.

[4] L. L. Padmaj P kumar*1, Najiya Masood*2, Sooraj Kumar S*3, Jismi Rajan*4, "Library Management Using RFID," *Int. Res. J. Eng. Technol.*, vol. Volume: 06, no. Issue: 05, pp. 1586–1592.

[5] I. Koneru, "RFID Technology : A Revolution in Library Management," *Library (Lond).*, pp. 11–13, 2004.

[6] R. G. Smith, F. D. Menalled, and G. P. Robertson, "Temporal yield variability under conventional and alternative management systems," *Agron. J.*, vol. 99, no. 6, pp. 1629–1634, 2007, doi: 10.2134/agronj2007.0096.

[7] S. Satrusallya and A. Wunnava, "RFID technology based library management system," *Int. J. Innov. Technol. Explor. Eng.*, vol. 8, no. 11 Special Issue, pp. 937–941, 2019, doi: 10.35940/ijitee.K1171.09811S19.

[8] M. Singh, "A snapshot of traditional library to modern library using bar code technology: an experience of central library GNDEC, Ludhiana," *J. Adv. Libr. Inf. Sci.*, vol. 3, no. 2, pp. 146–149, 2014.

[9] M. E. Bitter-Rijpkema, S. Verjans, and R. Bruijnzeels, "The Library School: Empowering the sustainable innovation capacity of new librarians," *Libr. Manag.*, vol. 33, no. 1–2, pp. 36–49, 2011, doi: 10.1108/01435121211203301.

[10] P. Grover and A. Ahuja, "Radio Frequency Identification Based Library Management System," *Int. J. Adv. Comput. Sci. Appl.*, vol. 1, no. 1, 2010, doi: 10.14569/ijacsa.2010.010107.

[11] F. Nisha, "Implementation of RFID technology at defence science library, DESIDOC: A case study," *DESIDOC J. Libr. Inf. Technol.*, vol. 38, no. 1, pp. 27–33, 2018, doi: 10.14429/djlit.38.1.12351.

[12] S. Vijayagowri and M. E. Mrs. B. Kousalya., "INTELLIGENT LIBRARY MANAGEMENT SYSTEM USING GSM AND RFID," *Int. J. Res. Comput. Appl. Robot.*, vol. Vol.4, no. 6, p. 33, 2016.

[13] G. Singh and M. Sharma, "Barcode technology and its application in libraries and Information centers," *Int. J. Next Gener. Libr. Technol.*, vol. 1, no. 1, pp. 1–8, 2015.

[14] E. Edwards and P. Orukpe, "Development of a RFID Based Library Management System and User Access Control," *Niger. J. Technol.*, vol. 33, no. 4, p. 574, 2014, doi: 10.4314/njt.v33i4.19.

[15] S. B. A. Hamid, A. Diyana Rosli, W. Ismail, and A. Z. Rosli, "Design and implementation of RFID-based anti-theft system," *Proc. - 2012 IEEE Int. Conf. Control Syst. Comput. Eng. ICCSCE 2012*, no. November, pp. 452–457, 2012, doi:

DOI: 10.31695/IJASRE.2021.34016

10.1109/ICCSCE.2012.6487188.

[16] D. Makhija and P. K. Chugan, "RFID Based Library Management System: The Benefits and Challenges," *19th Int. Conf. Manag. NICOM*, pp. 219–231, 2016.

[17] Y. Yuan and D. Yu, "UHF RFID shelf solution with cascaded reader antenna and positioning capability," *2012 IEEE Int. Conf. RFID, RFID 2012*, no. April 2012, pp. 149–156, 2012, doi: 10.1109/RFID.2012.6193043.

[18] D. L. A. Mansfield, "Reducing Book Theft at University Libraries," *Libr. Inf. Res.*, vol. 33, no. 103, pp. 10–15, 2009, doi: 10.29173/lirg98.

[19] A. Alexander, *Review of Public Libraries, Archives and Museums: Trends in Collaboration and Cooperation*, vol. 2, no. 2. 2010.

Author's profile

Deo Irankunda *born at Mubanga-Muhuta commune, Rumonge province of Burundi. He is a Msc candidate in Embedded and Mobile System, specializing in Embedded System at Nelson Mandela African Institution of Sciences and Technology. He has a background in telecommunications engineering and management in the specialty of Network and System securitiy obtained at Hope Africa University in Bujumbura Burundi. His interst lie in Information Communication and Technoloy of development in educational sector, Health and internet gouvernance.* Email: irankundad@ nm-aist.ac.tz

Ramadhani Sinde *works as lecturer in the School of Computational and Communication Sciences and Engineering (CoCSE) at Nelson Mandela African Institution of Science and Technology (NM-AIST). His research interests include Internet of Things and Embedded Systems, mobile computing, modelling and performance evaluation of wireless sensor networks, wireless and mobile communication. Sinde has authored and co-authored more than 10 papers in internationally refereed journals and conferences. He is a Queen Elizabeth Scholarship – Advanced Scholars Program alumni.* Email: ramadhani.sinde@nm-aist.ac.tz.

Neema Mduma *is lecturer the Nelson Mandela African Institution of Science and Technology (NM-AIST) in Tanzania. She has PhD and MSc in Information and Communication Sciences and Engineering from NM-AIST in 2020 and 2016 respectively. Neema is passionate about education particularly girls, and during her PhD, she developed a Machine Learning model called BakiShule which aimed at preventing students from dropping out of school. Neema's efforts towards women in science has been recognized and she was given an award from the L'Oréal UNESCO as 20 young talents in Sub-Saharan Africa for the year 2020. Her research interests are Artificial Intelligence, Machine Learning and Data Science.* Email: neema.mduma@nm-aist.ac.tz.

Dr. Mussa Ally Dida *is a Senior Lecturer at NM-AIST School of Computational and Communication Sciences and Engineering (CoCSE), Deputy Centre Leader of the Centre of Excellence for ICT in East Africa (CENIT@EA). He has a PhD in Information and Communication Engineering from Beijing Institute of Technology (BIT), China attained in June 2017. He has supervised/ co-supervised 14 Masters and 2 PhD students to graduation and he is currently supervising more than 10 masters and PhD students. He has published more than 40 papers in highly reputable journals. His research interests are in the areas of wireless communication systems, embedded systems, and IT systems development.* Email: mussa.ally@nm-aist.ac.tz.

DOI: 10.31695/IJASRE.2021.34016

Output 1: Poster Presentation

ELOPMENT OF RFID BASED LIBRARY MANAGEMENT AND ANTI-THEFT SYSTEM: A CASE OF EAST AFRICAN COMMUNITY REGION

Deo Irankunda

Programme: EMOS

CENIT@EA
Centre of Excellence for ICT in East Africa

INTRODUCTION

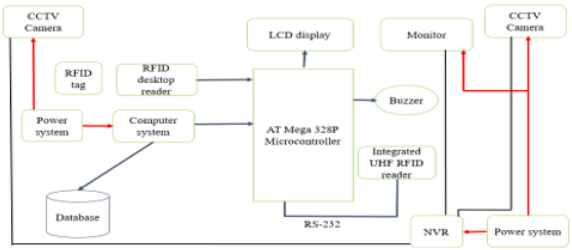
The existing Library management systems require human efforts, and manual recording in excel sheets and/or on paper. For huge Library operations, scenario is very hectic to keep track of. Use of Radio Frequency Identification known as RFID technology reduces human efforts as well as errors. So, the RFID based smart library system is proposed to solve these issues. For a big Libraries, it will be an effective system. The approach in this project realizes intelligent management of an automatics Library. The aim of development of this system is to basically reduce human interference and apply smart technologies which are related to automation field to our day to day applications and make library users more comfortable.

Problem statement

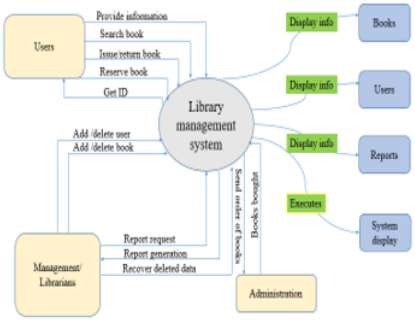
While libraries are growing in size, the problem associated with maintenance and security is also increasing. Nowadays, manual library managements systems are more vulnerable to many disadvantages which induced in most cases to be replaced by automated systems. Furthermore, libraries around the world are facing major problems such as theft of library items, page removing and time-consuming. Theft is mostly done at a higher level and brings a negative impact by affecting library finance, archives of different types as well as academic objectives

Methodology

1. System block diagram



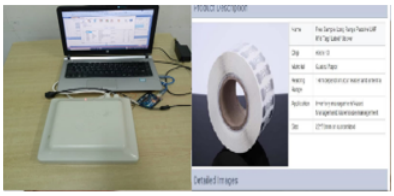
2. Data flow diagram



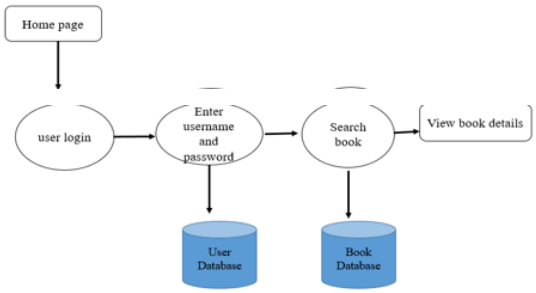
CONSTRUCTION/ALGORITHM

Prerequisites:

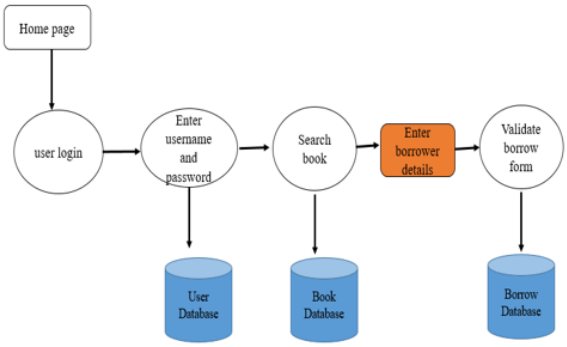
- Arduino UNO
- UHF RFID
- UHF RFID cards
- A laptop
- USB cable
- Connecting wires



Book search



BORROW PROCESSES



RESULT/APPLICATION

The system is successfully developed and implemented to speed up Library operations. This is applicable to any warehouse not limited to EAC library

CONCLUSION

In this System, a RFID-enabled Library management system is proposed to keep all library resources well managed, secured as well as granting a high level of accessibility. This project focused on the use of Ultra High Frequency (UHF) band which enable readers and tags to send and receive data at longer range compared to other frequencies bands.