Design and Development of E-Library System: COVID-19 Pandemic Challenges

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Abstract The education sector in the recent past has had changes in policy as a result of high transition rate target, innovation, infrastructure technology advancement and COVID-19 pandemic challenges. In keeping phase with this great achievement and challenges, there is need to incorporate innovations in Information and Communication Technologies in providing library services in education sector in order to have efficient, secure and quality services. In this research project we have investigated the problems with the past and current library systems, then analysed, designed and developed a prototype that would greatly contribute in improving the provision of the library services. The prototype would manage tasks that include appointments, lending, reserving, returning, processing payments, storage of book records, provide information and processing invoices for orders. In reducing the unauthorized access of book records from unauthorized persons, we have described the encryption and accessing of pages security plan for the emerging threats. The system would be accessed in local and unlimited networks but in the areas where there are challenges of connectivity, high internet costs and poor infrastructure we intend to use offline web services and connect only when the service is required and necessary. The development methodology adapted in the development process phases of the electronic library system is the spiral development methodology.

Keywords*: design, security, spiral, methodology, COVID-19 pandemic, electronic technology*

1. Introduction

In achieving universal and expanding education to all, the United Nations Development Programme (UNDP) initiated the Sustainable Development Goals (SDGs) at the United Nations Conference on Sustainable Development in Rio de Janeiro in 2012. The United Nations has dedicated one of the eight sustainable development goals to education [1], but this is possible if the learners and researchers access the materials, resources and services that are relevant and up to date or current. This is possible only if the library services and resources of eBooks, videos and digital content are easily available at affordable costs. In this research project the focus is to study the systems and come up with the solution that will contribute in improving the library services so as to achieve the objective of training personnel for development in reducing illiteracy and offering quality education services in undeveloped and developed countries.

The integration of Information and Communication Technologies (ICT) in the provision of library services has a great role to play due to ability to improve service delivery. In developing and developed countries there has been attempts to incorporate technologies in delivery of such services in most of the existing systems but most of these systems have either been ineffective or lack components that fully meet the expectations of users in academic institutions or organizations in delivery, operation and management of the services. In achieving the task of Design and Development of E-Library System, the first task is to investigate and identify the weakness of the library systems. Secondly, clearly state the problem and objectives then explore the methodologies that would accomplish the task. Thirdly, develop a prototype that will address the weakness of current library systems. Finally, test, maintain and distribute software to users for evaluation.

1.1. Electronic Library System

An electronic library system is formally defined as the system that use Information and Communication Technologies (ICT) in providing services and set of documents through electronic means using digital technologies that allow for the retrieval, archiving, preservation and dissemination of those documents and services online. This is achieved by cost effective and secure use of Information and Communication Technologies in providing and managing library services that includes but not limited to registration, reservation, lending, returning, ordering and payments for lost books, payments of stocks and payments of fines for the overdue books. The involvement and integration of Information and Communication Technology in provision

of library services has numerous benefits that include the following;

i)   The electronic library services provide online and offline storage of documents and services that simplify and enhance the learning process.

ii) The provision of unlimited access to library resources that include eBooks, journals and videos from anywhere at the convenient place and anytime.

iii) The academic institutions libraries benefits from scalable infrastructure, role-based secure access, high performance and reliable to ensure seamless access to library resources.

iv) The system provides management with unlimited access to search the library catalog, schedules, books and resources from anywhere, anytime at convenient location.

v)   The system improves the performance of libraries with dynamic reports, charts and graphs to review and track the progress for better decision-making.

vi) The electronic library system is developed for easy entry of data that makes library services and operations free from errors.

vii) The electronic library system can easily be fully customizable and adaptable to the needs of educational institutions to provide fast, reliable and secure services.

viii) The choice and embracing sophisticated technologies is cost-effective and a viable choice for education institutions the use of digital libraries eliminates paper-based processes and maintenance overheads, improves productivity, reduces operation costs and saves time.

These benefits are realized in academic institutions and organizations that invest in Information, Communication Technology (ICT) by acquiring the electronic library system, personal computers, training of personnel, networking computers and maintaining the internet access in education providing institutions. These benefits are achieved if governments and private sector have joint partnership in providing recourses that will improve the infrastructures to enable the provision of the electronic library services.

In order to encourage stakeholders in institutions that are still using the partial automation of library services that have had challenges in the recent past especially during the outbreak of COVID-19 pandemic (disease caused by the severe acute respiratory syndrome virus 2 [SARS-COV-2]) due to fear of loss or change of jobs, there is need to sensitize the service providers on the benefits of the use of electronic library service systems in organizations and academic institutions. These benefits that are realized gradually includes, reduction of redundancy, reduction of information duplication as there is no more manual receipting of payments that requires balancing of accounts books every financial year, reduction on time spent on long queues during renewal or returning of books that is normally witnessed during closing times as the time of operation is limited to working hours of the working days, the errors that are incurred while lending books as a result of illegible account numbers or manual input are reduced to minimum and lastly but not least, the introduction of the system will open training opportunities in new technologies and not lead to loss of employment as perceived by many people in institutions and organizations whenever there is an introduction of automated systems.

In designing the electronic library system, the aim is to have the operations that are currently handled manually or are partially automated to be fully automated. In particular, the proposed system will fully address the concerns that have been witnessed in already existing systems that include the manual handling of books when borrowing or returning, manual receipting of fine payments, manual reservation of books and manual monitoring of order payments that made the already existing systems inefficient.

1.2. Statement of Problem

The problem in this research project is to develop and demonstrate electronic library system prototype that would store, retrieve and manage books' records of lend, return, renew, reserve, process fine and process lost books' payments in supporting the provision of quality, affordable and secure services for all using appropriate and scalable technologies.

1.3. Objectives

1.3.1. General Objective

The general objective of the research project is to study, analyse, design, test and implement an affordable and comprehensive electronic library system in approved and registered education providing institutions and organizations.

1.3.2. Specific Objectives

a) Study and identify the weaknesses of existing electronic library systems.

b) Design and develop database managed to store books' records for easy retrieval in providing the necessary information to students, researchers and management in education provision institutions.

c) Design fast, reliable, secure and effective electronic library system that would store and integrate records of appointments, reservations, lending, returning and payments for effective delivery of library services in academic institutions and organizations.

d) Develop secure, dependable, efficient, affordable and usable electronic library system using appropriate and scalable technologies.

1.4. System Requirements and Specifications

The system user requirements of the proposed system is intended to bridge the gap resulting from ineffective existing systems that have not met the user expectations. The user requirements for the proposed electronic library system includes the registration of members, management of book records of reservation, lending, fine payments and appointments. In the proposed electronic library system the system requirements specification [2] includes the following;

i)   The user shall be able to register as a member, supplier or employee on a presented electronic form where the user is required to fill biodata.

ii) The system shall allow the user to search information on books, journals, videos and digital materials.

iii) The user shall be able to register new books, journals, videos and digital materials.

iv) The user would conveniently make appointments or cancel appointments.

v) The system would allow payments of fines for overdue books, payments of lost books, videos, digital materials and journals from user commercial accounts.

vi) The stored biodata shall be altered by filling the update electronic form whenever there is change or variation of the current compared to the initial submitted data during registration.

vii) The system shall generate reports on request and users shall be allowed to view the appropriate relevant information.

viii) The system shall be available 24/7 for the users.

ix) The system would meet the standards of good software qualities described simply as maintainability, dependability, efficiency and usability characteristics.

1.5. Justification of the Study

The research project is an important study due to the increase of enrolment as a result of change of policy in the education sector that target the 100% transition rate at all levels. Secondly, due to the COVID-19 pandemic the students and employees are advised to work from home as a measure of keeping the social distance and avoiding contact, since operations in all sectors need to work normally and optimally, then the solution is to make sure most of the operations and services are automated. This will then eventually lead to reduced long queues seeking for services at the libraries and will be in line with the ministry of health protocols and guidelines for COVID-19 pandemic.

2. Literature Review

The involvement of Information and Communication Technologies in the education sector has remarkably changed the provision of education. In the United States the libraries are slightly involved in providing electronic library services, for instance the public libraries provide mobile libraries services of Google guidance location, eBooks retrieval services, video and audio download [3]. The functional requirements of the system design for these systems are based on atomicity, uniqueness and principle of reducing redundancy. The introduction of new technologies in academic institutions is the trend in the operations of internal management activities. These technologies include software for financial management, electronic learning, archival management, student management systems and library systems [4]. The libraries in academic institutions are important as the institutions and organizations ranking depends on how well they support programmes with the print and electronic resources [5] services.

In the past, library services were only available at the location of the library buildings in the academic institution and organizations but in the recent times this has changed due to the introduction of new technologies in the provision of services such that the library management systems are now established as tools tasked to offer operations and services [6] of online public access catalogue and circulation. The open source systems have in the past been preferred as alternative to the expensive proprietary software and have found a market in many institutions especially in developing countries due to the independence, low cost of implementation and maintenance. Further, the open source are free from costs of subscription and the buyer has the provision of modifying the software to suit the organization needs, an opportunity that is not granted in proprietary systems [7]. The requirements and infrastructure for the initiation of automated library systems in institutions and organizations have been defined that may include computers, supporting hardware, networks connectivity requirements and standards [8]. The absence of reliable network and larger bandwidth [9] will result in slower and ineffective system that may not be reliable in providing services. In order to improve the connectivity and reliability of the services in the proposed system, the consideration of using networks with larger bandwidths connectivity [10] subject to available resources will be given a higher priority.

The main objective of the library system has been given as providing up-to-date and availability of the services at all times with minimal errors in the local and limitless geography wide area networks. This system can be faulted as one that has emphasis on the services of learning materials of eBooks, videos and digital records but most systems have not incorporated the services like the payments of lost books, fines of expiry books and the long queues witnessed in most libraries. The inclusion of the components of appointments and payments will be a milestone in the provision of the services. However, the problem of authentication of the information that is available in the internet remains a challenge in the past and present systems. In the proposed system security and access of services and resources from credible and recognized sources would be top priority and the system will only store and access information from recognized sources [11].

3. Methodology

In developing well-structured and quality software product that is delivered in good time, it is good practice to prepare a document that outlines the phases and detailed description in each of the process phases that the developer wishes to adopt in the system development process. This document is normally prepared before the start of the development of the software product and acts as guiding document that may be used in developing the software product. A well prepared document will indicate and give evidence of technical understanding of the electronic library system that need to be developed that will ultimately meet the user's requirements. The preparation of this document will therefore enable us to achieve the objective of producing quality software that is reliable, usable, reusable, maintainable, portable, robust

and efficient. The classical phases of the software development process include requirements, specification, analysis, design, implementation, testing, deployment and maintenance. The selection of the software development process methodology is an important decision that programmers have to make as the methodology lays down the rules that delivers a credible and well-structured working system product. The methodologies that evolve systematically and predictable system software are the waterfall methodology, spiral methodology and iterative methodology [12]. In this research we adopt the spiral methodology as described below.

3.1. Spiral Methodology

This is the development of management system that is flexible compared to the waterfall methodology. In spiral methodology there is an attempt to produce a complete system product on completion of every cycle where each subsequent cycle involves improved requirements, specification, analysis, design, implementation and testing phases. In the first cycle, the first version of the system that runs but may not be perfect is made available and documented. The process is repeated in the second, third and subsequent cycles until a satisfactory system product is produced and documented. When all the phases are completed to the acceptable standards and documented the product is then deployed and finally the maintenance phase is carried out that will gradually meet the users' specification [11] if it is successfully completed.

The spiral methodology mainly focuses on adaptability and is suitable methodology whenever system developer wish to reduce overheads, for instance, the rationale, justification, documentation and development meetings. In particular the spiral methodology is favourable when system requirements are changed from the initial requirements as a result of change of mind in the part of the client or due to change of technology. The process phases of requirements, specification, analysis, design, implementation, testing, deployment and maintenance are depicted as shown in Figure 1. There is one common weakness to the iterative methodology that makes it

unpopular as compared to the waterfall, agile and spiral methodologies, that is, it does not have good documentation and therefore not well structured that would eventually make the electronic library system difficult to evolve and maintain. In this project we would adopt the spiral methodology and not the waterfall, agile or iterative methodologies due to its strengths that include the following;

i)   Risk management is easy in this type of model. When you are handling expensive and complex projects, risk management is a must. Moreover, Spiral model has the ability to make any software testing project transparent.

ii) The customer can see and review the test and different stages

iii) The projects can be separated into groups to make the management of the various components easy and manageable.

iv) The documentation is systematic and can be controlled for better management

v)   The project development will be well planned and more realistic as development progresses.

In the development of the proposed electronic library system the first phase would be to identify the electronic library system requirements and specification once the system objectives have been specified. This is followed by the system analysis phase where the use cases and actors are identified and modelled. Since the methodology chosen is spiral, testing will be run after the development process. When the design phase is complete and documented, it is followed by the implementation phase where the design is translated into algorithms and the source code. Again during the implementation phase, the phases of requirements, specification, analysis and design are refined to improve the software product. The testing phase commence when all the phases of requirements, specification, analysis, design and implementation are complete and documented. This phase involves the evaluation of the product using the test data that would be stored in the database. The faults that are identified in this phase are corrected as well as the revision and refinement of the previous phases to reflect the new development changes in the electronic library system product.
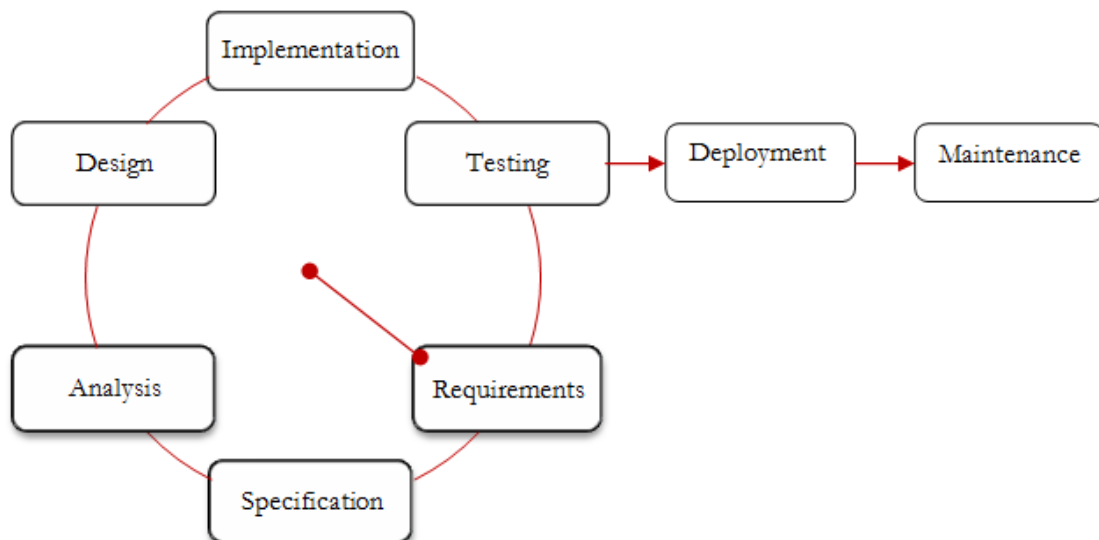

Figure 1. Spiral development methodology

3.2. Operating Systems

The programs that control the execution of application programs and act as an interface between applications and the computer hardware are referred to as Operation Systems. The main objectives of the operating systems include provision of interface that is convenient for the computer users through its service programs that manage the hardware and software, enables the users to use the computer resources and manage hardware efficiently, protects the computer resources by controlling access to the use of the computer and enables only people authorized to use the computer resources access [13]. An operating system that will guarantee the security will not only safeguard the information of organizations but will also result to people and organizations having confidence with organizations that protect their privacy especially if the stored information is personal or private. There are many operating systems available for developing the electronic library software product. The selection would be from the commonly used operating systems and not limited to Windows, Linux and Mac operating systems. The factors considered for the decision of selection of a suitable operating system for developing the electronic library system are based on the strengths that includes the cost, reliability, security features, support of the hardware devices and complexity of the operating system

An operating system that meets these requirements is the Linux operating system. First, Linux is an open source operating system, hence no cost required to acquire the operating system as compared to for instance the windows operating system. Secondly, Linux is reliable as compared to Windows. Thirdly, Linux is more secure than its competitors, even though it can also be attacked, but overall it is better than the competitors. Fourthly, Linux supports a variety of hardware devices even though Windows operating system is still rated high when considering the usability, easiness and compatibility. Considering the strengths of Linux and other operating systems, Linux is a better selection as compared to the other existing operating system [14] and therefore we recommend that we adopt the Linux as the operating system of choice for the electronic library system.

3.3. Programming Languages and Database Management Systems

The electronic library system application would be developed in Java object-oriented programming language. The decision for the election of Java programming language has been arrived at after considering, comparing and evaluating the core features of Java language and other object-oriented programming languages. The Java language has been rated highly in creating powerful applications with outstanding features that includes being well structured, well designed, platform independent, secure and robust [15] programming language.

The Database Management System (DBMS) that is proposed for development of electronic library system is PostgreSQL and the reasons for this decision are based on the factors that includes, first PostgreSQL is an open source object-relational database system and therefore there is no cost required to acquire the system, secondly, it

is portable and therefore can be run on a number of versions of Linux, UNIX and Windows Operating Systems, thirdly, it has programming interfaces for a variety of programming languages that includes C++, Java, Perl, Python, ODBC and JDBC, fourthly, it is considered fast as compared to Oracle and other object-relational database management systems, fifty, it is stable and compliant object-relational database management system and lastly but not least, it is available, flexible and has security features that are considered compliant to the required standards of a secure and scalable system.

3.4. System Constraints and Challenges

The proposed system is expected to have constrains and challenges while providing the library services. First, there are projected connectivity challenges as a result of poor telecommunication infrastructure, high internet connection costs and lack of access to international bandwidth in most of the undeveloped and developing countries. Secondly, the services provision requires well trained personnel in information and library management skills to effectively provide the services and maintain the system. However, persons with these skills are rare compared to the population seeking the services in many undeveloped and developed countries.

4. Analysis and Design

4.1. Analysis

The analysis of the existing systems plays a major role in developing software as it is the stage where system specifications are modelled. The requirements specifications are commonly modelled using Unified Modelling Language [16] techniques. The preferred and usually used unified modelling language technique in object-oriented analysis is the use case diagram. In collecting and gathering information on the requirements of the electronic library system various methods considered for the purpose includes, interviewing library service providers, interviewing education services beneficiaries, observing and participating in using current operational library systems, studying and analysing library systems and studying and analysing library system documents.

The study of library documents, interviews of stakeholders and observation of the systems currently in operation in many countries reveal that the systems are inefficient in service delivery and lack subsystems that effectively manage appointment schedules, payment of fines, reservation, lending, returning and managing the journal and digital material records [17]. The proposed electronic library system is expected to address the current system faults and incorporate the concerns of the stakeholders and users so as to evolve an efficient, credible, scalable and secure system. The electronic systems in the recent past have had some of the components integrated with information and communication technology but there has never been an existing electronic system that is efficient, credible and secure that comprehensively satisfies the requirements of education service seekers in many countries as there have been reported complains of

inefficient delivery of services due to fault system or lack of some crucial components that are important in order to evolve an electronic system that is operational and provides services optimally.

4.1.1. Use Case Diagram

The construction of the use case diagram represents the modelling of use cases identified to capture the system specifications that are feasible to individuals or subsystem in the proposed electronic library system. The individuals and subsystems that interact with the identified use cases are commonly referred to as actors. The identified actors in the proposed electronic system are mainly classified as non-members and members. The specific actors identified in the proposed electronic library system includes but not limited to librarian, member, accountant, administrator, vendor and non-member. The use cases are modelled as represented in the use case diagram in Figure 2.

4.2. Design

The design of the system is the crucial and important phase of system development where system specifications are modelled using class diagrams and construct user interface diagrams that may be used in capturing new inputs, editing and displaying system information. Since the system will require the storage of data, the class diagrams will then finally be translated into relations while the attributes will be the columns in developing the database. The class diagram is a Unified Modelling Language technique commonly used in developing object-oriented solutions. In designing our solution we need to identify classes, attributes and operations for the electronic library system. The classes identified for the system includes the member, employee, appointment, account, payment, supplier, book, order, lend and, reserve.
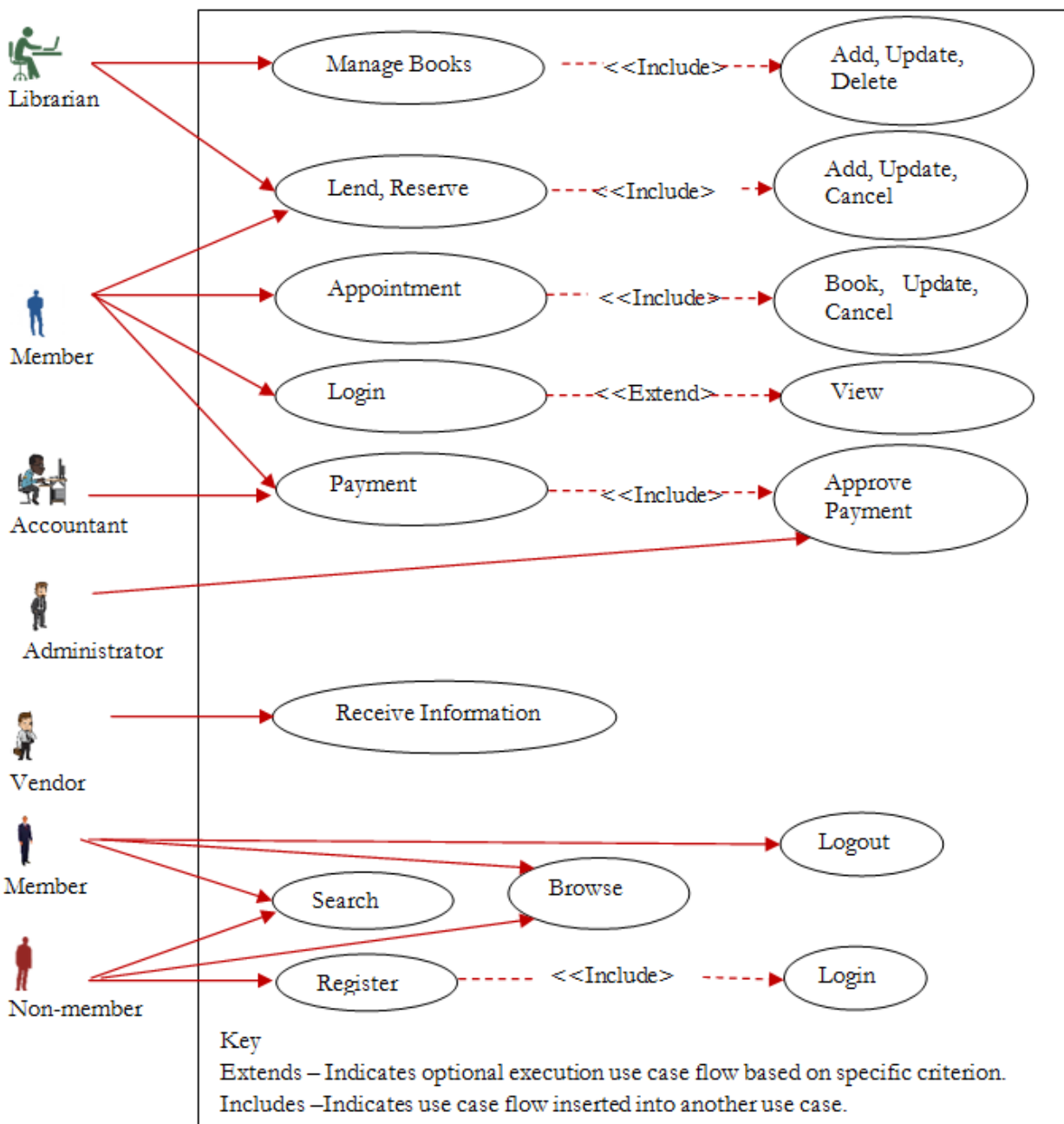

Figure 2. Use case diagram

The process of using set of restrictions to exclude certain undesirable properties in the design is referred to as normalization. The normalization process is given a high priority in design of systems since it leads to well-designed database by reducing the amount of duplication, storage space requirement and update anomalies and improving the natural representation of information in the database. In order to construct the class diagrams, the classes and relationships are represented in the class diagram. All the possible relationships are considered and all those relations that are found to be many-to-many are further decomposed to one-to-many while those that are found to be one-to-one relationships are discarded from the final class diagram.

The decision on the selection of data types for the attributes depends on the size of the value stored and the nature of manipulation expected on the data value. If the data value is involved in computation then integer is appropriate if the data value is a whole number while double is selected for the data value that comprise of both whole number and fractional part. The data values that are not used for manipulation for instance the identification data values the string data type are commonly used because they have good concatenation properties and wide range of data values as they use the characters 0 - 9, a - z and A - Z.

4.3. Sequence Diagram

The sequence diagram is usually constructed due to its importance in validating the logic in the description of electronic library system and help in detecting unforeseen defects in the design. In the system we construct the sequence diagrams for validating new member registration, member login and employee login as shown in Figure 3a - Figure 3c. In Figure 3a the new-member makes a request to register as new member by clicking the register button on the home page. The new member then input personal information that includes number, name, address, phone and email. The electronic library system validates the new member information and sends feedback to the new member that the registration is either successful or unsuccessful.
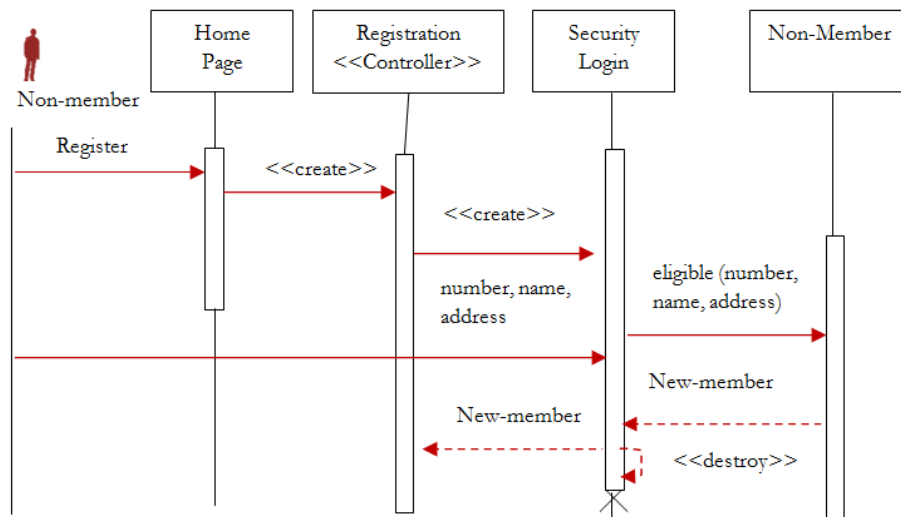

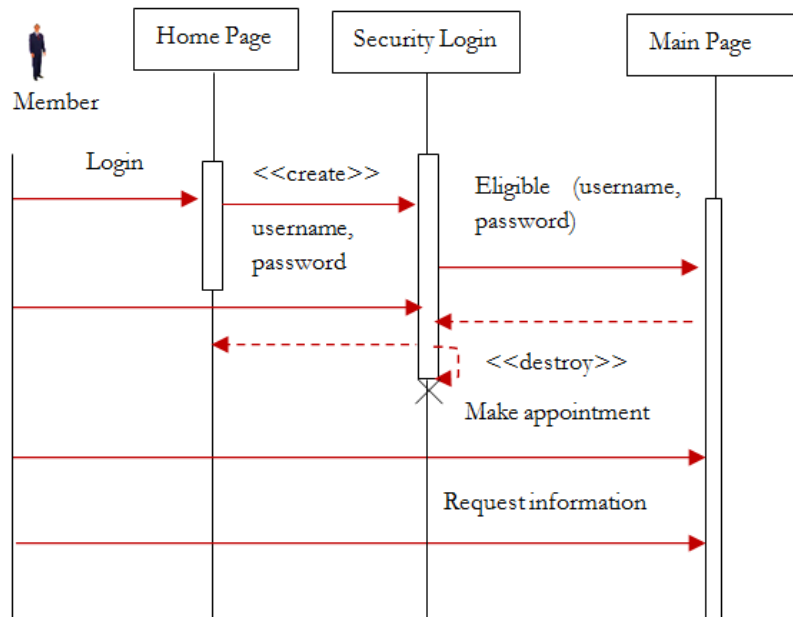**Figure 3a.** New library member registration sequence diagram

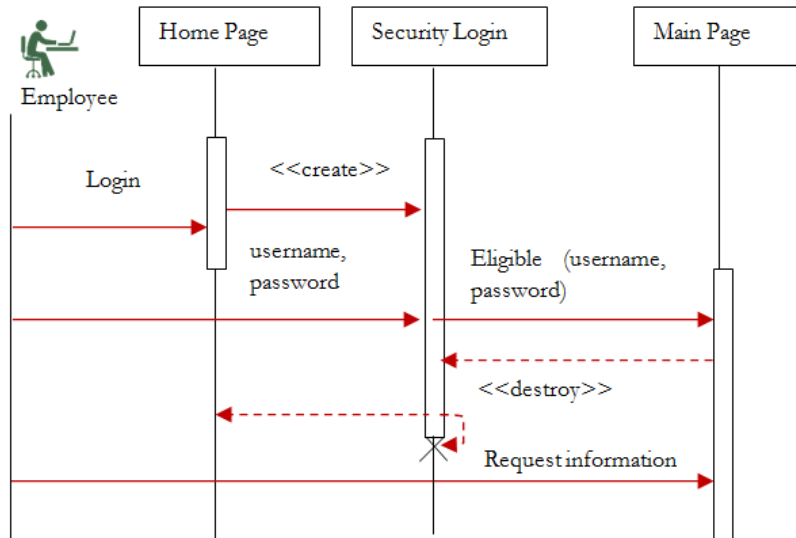**Figure 3b.** Library member login sequence diagram

Figure 3c. Library employee login sequence diagram

In Figure 3b the member makes appointment request by clicking the login button on the home page, then input the username and password. The system validates the member login information and gives feedback to the member that may be the main member page or login unsuccessful message.

In Figure 3c the employee who may be the librarian, accountant, administrator or system administrator requests members' records information. He/she first clicks the login button on the home page and then inputs the username and password. The system validates the employee login information then gives feedback to the employee that may be main page on successful login if the credentials were correct or homepage if login was unsuccessful due to incorrect credentials.

4.4. Database Development Design

The database development is an important process that requires well planned and properly set rules and standards in order to evolve quality, consistent, secure and well-structured system. A poorly designed database may lead to inconsistence, breach of privacy, redundancy and loss of business if the database does not meet the specifications, targets and objectives for which it is designed, that are broadly given as the ability to support relationships among the relations, provide solution to problems for which they are designed, impose integrity constraints, improve efficiency and accommodate emerging challenges.

The hierarchical, network, relational database and object-oriented relational database models are commonly used in developing the databases. In this research project, we adopt the relational database model for development due to its strengths that includes storage of standardized data format, allows users to simultaneously access consistent data, requires less memory due to storage of data free of redundancy and incorporates data integrity features in its design that are adequately enforced [18]. The development process is systematically carried in two phases that are commonly referred to as the logical and physical designs.

4.4.1. Logical Design

In the logical design phase the main entities and the relationships between the entities are identified and an entity-relationship diagram constructed which is a useful tool in modelling relations and relationships. In constructing the entity-relationship diagram for the electronic library system, first identify the concept about which the data of name, identification or address for instance is stored referred to as entities that may either be object, institution or person.
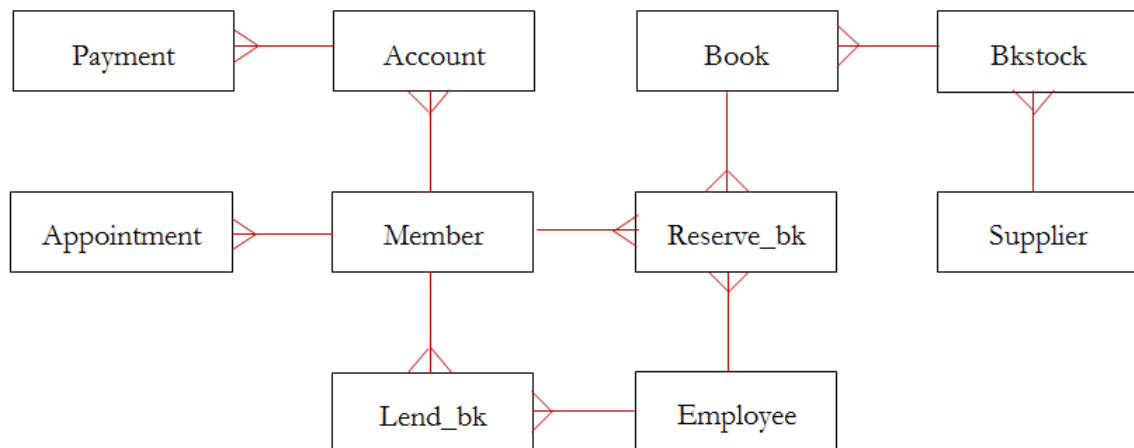

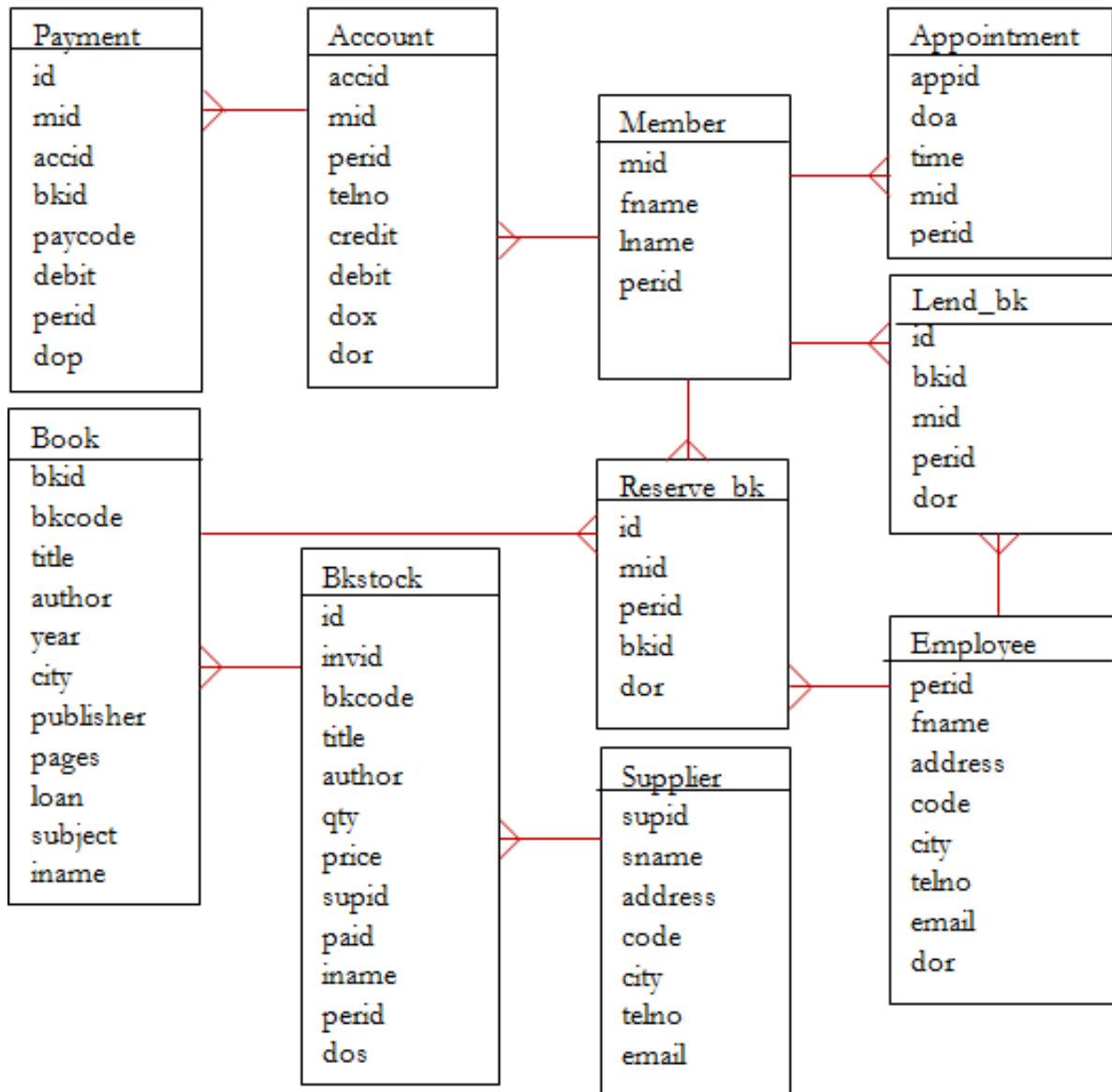**Figure 4.** Library entity-relationship diagram

Figure 5. Library conceptual model

The entities identified for electronic library system includes book, member, payment, account, appointment, employee, lend, reserve, stock and supplier. The relationships between entities indicates the sharing of data between entities that may either be one-to-many or many-to-one as shown in Figure 4. Next, identify the attributes of each and every entity or relation by observing current library systems, the documents and reports of library systems and the requirements specification of the proposed electronic library system. The entity relationship diagram is crucial as it relates and validates the relationships between the relations that guides in making a decision on whether additional relations or discarding relations is appropriate. The relations that are normally discarded are ones that have one-to-one relationship while the relations with many-to-many relationships are modelled to include additional relations since the many-to-many may lead to undesirable effects in the design of the database. The modelling of relations, attributes and relationships between the relations is represented in the conceptual model shown in Figure 5.

4.4.2. Physical Design

The representation design of the data in the physical representation of the logical design in a system is referred to as the physical design. The first task in the design is to identify attributes that are unique for every row in the relations, then based on personal preference, judgement and convenience, select the primary key for each of the relations from the attributes of the relations. In instances where there are more than one candidate key, randomly pick one of them, but if there is no unique candidate key, then explore the possibility of combining two or more attributes or include a new attribute in the relation that will have the unique property for every row or record. In order to relate the relations, we could include the primary key attribute of a relation in relation or relations that we wish to relate the relation. This would enable the user to extract related information more efficiently from relations where it is currently being held. The representation of the relations, primary keys and foreign keys of the proposed electronic library system is depicted as schema diagram shown in Figure 6.
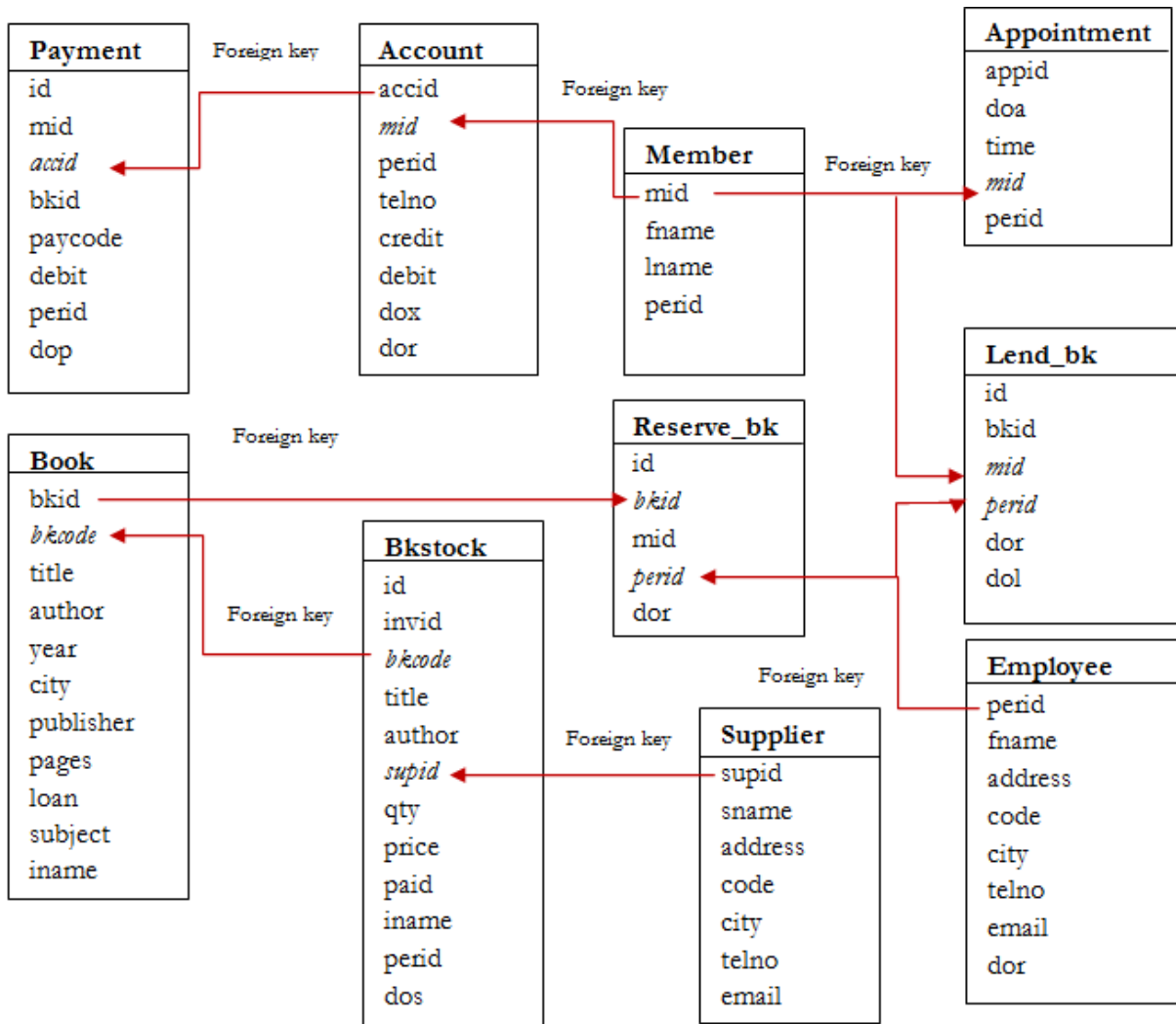
Figure 6. Library schema diagram

In member relation all the possible attributes that are unique in every row in order to determine the primary key are considered. The attribute member number is the only possible candidate key. The member number attribute is then selected as the primary key for the member relation. The next relation employee has candidate keys of employee number, telephone and email. The employee number is conveniently selected as the primary key for this relation. The supplier relation has the supplier number selected as the primary key as well.

In the book relation, we have the book number, book code, title, author, year, city and publisher as the possible candidates. The book code is conveniently selected as the primary key in this book relation. The stock relation has stock number and invoice number as candidate keys. The stock number subjectively selected as the primary key. The reserve relation has reserve number as the only possible primary key and therefore it is selected as the primary key for the reserve relation. The lend relation has lend number automatically generated and becomes the primary key for lend relation.

In the payment relation, we have the payment number automatically generated as the only possible primary key in payment relation. The account relation has account number as the only possible primary key and therefore selected as the primary key. The appointment relation has appointment number as the only possible primary key and therefore it is selected as the primary key for the appointment relation. The book, stock, lend and reserve have book number, stock number, lend number and reserve number selected as the primary keys as well.

In relating the relations directly, the foreign keys are established. The first relation payment can be related to account relation by including the account number in the payment relation. The second relation member can be related to the account, appointment and lend relations by including the member number in the account, appointment and lend relations. The book relation can be related to the reserve relation by including the book number in the book relation. The supplier relation is related to stock relation by including the supplier number in the stock relation while the employee relation is related to reserve and lend relations by including the employee number in the reserve and lend relations. In order to take into consideration the data precision, storage memory requirement and efficiency in processing, appropriate size and data type for each of the columns in the physical model design is given a priority consideration as it plays an important role in database design development. In addition to the selection of correct data types the integrity constrains are carefully enforced.

4.5. User Interface Design

The design of user interface requires skills and input from various expertise in software development that includes the graphic designers, system analysts, programmers, engineers, information records personnel, accountants, managers and stakeholders [19]. In this research project the user interface was developed based on the user requirements specifications in which the main guiding principles considered includes the system qualities of navigation, accessibility, visibility, usefulness and feedback [20].

In the initial stages of developing the user interface, the sketches are drawn based on the use cases of login, search, add, update, delete and display books' information of users and services. Since the actors have varying privileges, the pages are designed for categories of users that are broadly classified as non-members and members. The members are further categorised as members, lenders, suppliers, accountants, administrators, librarian and system administrators. The actors are assigned appropriate interfaces as a measures of making the system secure in order to reduce the chances of unauthorised access to records and services. In the home page usually accessed by members and non-members, the user is allowed to browse, search, register or login. Once the individual seeking the services has registered, he/she can now access the main page as depicted in Figure 7 using the authorised personal security credentials.

The home page sketch in Figure 7 would then be designed in order to obtain home page that the user would use to search, browse, login or access the home page menu where the user can click the buttons to display the registration form for registration as a member, employee or supplier as shown in Figure 8. If the user wishes to register as a member, then he/she would click the register button to access an electronic registration form shown in Figure 9 where the user would fill the personal information of first name, last name, address and contact information. On completion, the user would then click the register button to submit personal information or click cancel to discard the filled information.
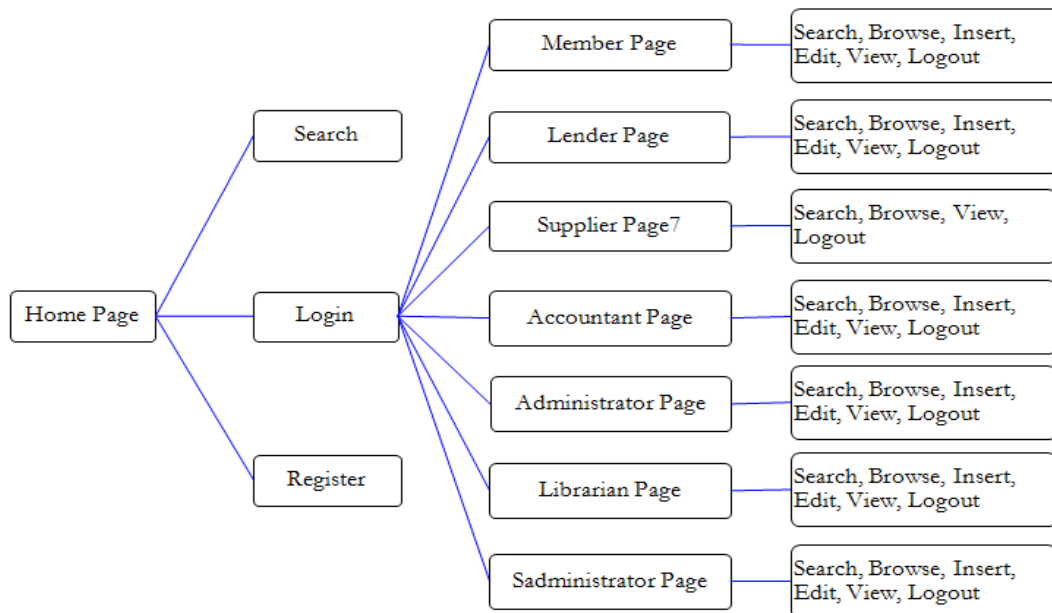

Figure 7. Electronic library system pages design

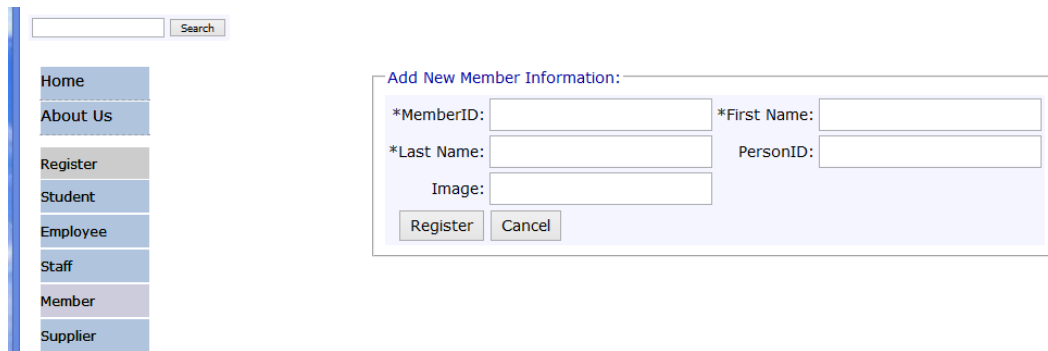**Figure 8.** Electronic library home page interface

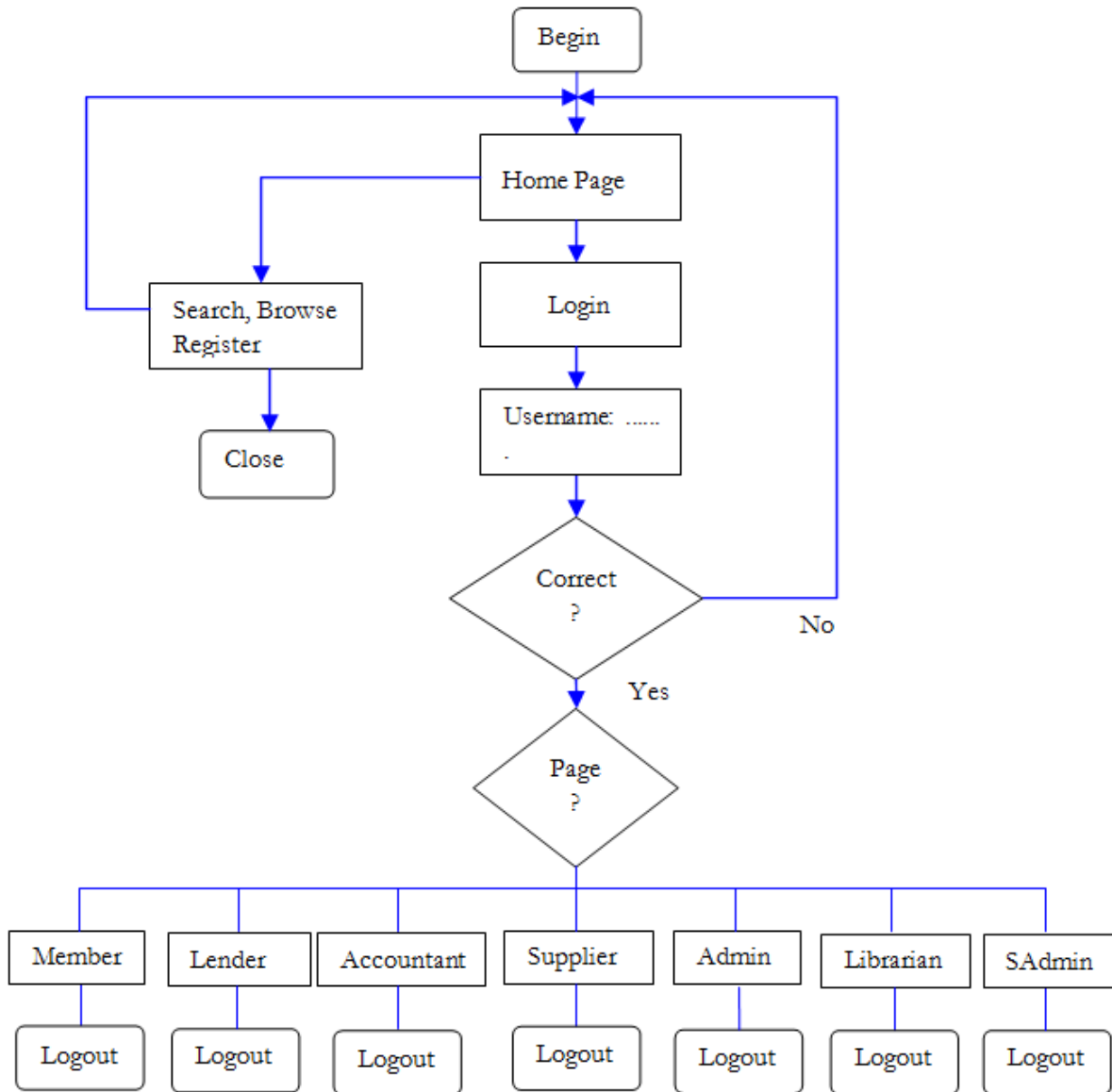**Figure 9.** Registration form

Figure 10. Login design

If all the information is correct and complete, the user would be sent a notification of successful registration otherwise the user would be notified of unsuccessful registration. The correct information would then be processed by the administrator who will accept or reject the request of registration. If the administrator approves the request, the user would be notified of the acceptance of registration request and would also be sent the identification number, username and password through the email address that would be used in subsequent system login, identification and reference whenever the user seeks electronic library services. In order to login, the user need to click the login button on the home page, then type username and password and clicks login button. If the username and password are correctly filled, the user will access the member, lender, accountant, supplier, administrator, librarian or system administrator page if the login credentials were given in the order listed respectively as depicted in Figure 10.
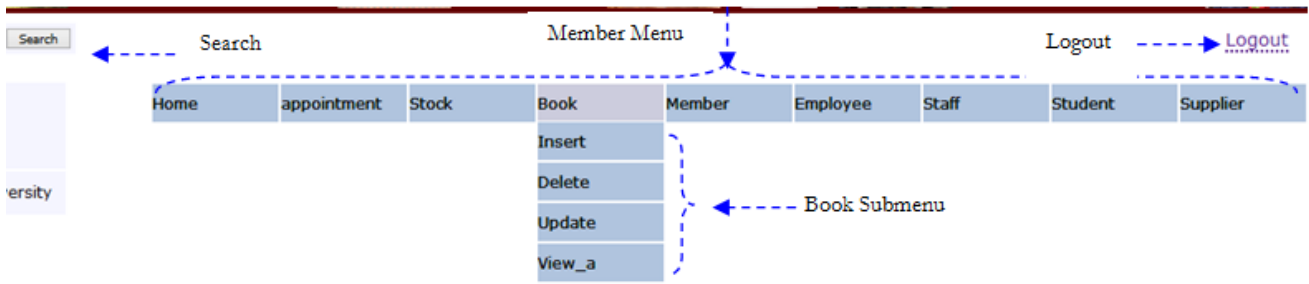
Figure 11a. Member mainpage interface

If user login is successful, he/she will access the main page that will have the options of search, logout and main menu depending on the user login credentials that may be as member, lender, accountant, supplier, administrator, librarian or system administrator. The main page menu for system administrator has home, appointment, stock, book, member, employee, staff, student and supplier. In the book menu we have submenu insert, update, delete or view as

depicted in Figure 11a, where the system administrator would insert new records, edit, delete or display books' records.

If the system administartor wish to add or edit or delete or display then he/she need to click the appropritae option that may be insert or update or delete or display. The interface for insert, view, update and delete books' records are as shown in Figures 11b - 11e respectively.

Figure 11b. Insert book record

Figure 11c. Display selected books records

Figure 11d. Update book record

Figure 11e. Delete book record

5. Development Process Cycle, Conclusion and Further Research

5.1. Development

The development of the electronic library system involved and implemented the five phases of secure software development life cycle that includes the phases of implementation, testing, security, deployment and maintenance as described below;

a) **Implementation**

The implementation of the electronic library system involved writing source codes for login, searching, validation, registration, insert, edit, delete and display records.

b) **Testing plan**

The strategy of testing the system before the launch in the institutions and organizations will involve testing each sub-menu of the system using appropriate test data. This is important as it validates how the system would function as per the set specifications and standards to the satisfaction of the users and stakeholders.

c) **Security**

The electronic library system would store and allow retrieval of books records and information transmitted across networks in education institutions, organization and homes that need to be protected from the unauthorised individuals or virus attacks. In protecting the stored records, the first measure is to train system users on the dangers and effects of the virus attacks. The electronic library users are further encouraged to use updated antivirus software and make backup copies of books' records regularly that would be used in the event of virus attack on the electronic library system. The second security measure is to make sure authorised persons access library services by implementing the using of access login credential whenever a person seeks library service online to avoid persons who might be having ill intentions or simply persons whose intention is to sabotage the services for personal gains especially the education service providers' competitors.

In order to protect data over local and unlimited networks, there is need to have digital encryption and decryption to enable the data and information transferred over the networks to be transmitted safely and secure. In encryption substitution, transposition, XOR logic and Rivest, Shamir Adelman (RSA) algorithms have been developed and considered appropriate methods of encryption in the proposed electronic library system. In evaluating the encryption algorithms, the RSA algorithm is more secure encryption standard compared to the competitors algorithms because of its large key size ranges and factorization of large numbers based on number

theory. In addition to encryption, information sent across networks would have digital certification that would enable the recipients to receive and access library records and services from known sources.

d) **Deployment**

The deployment of the electronic library system product involves the distribution and installation of the product in the education and research institutions. The first step in the process phase is to carefully plan the deployment strategy for marketing and installing the software product. This involves preparing the software product copies, licenses and setting up a team of persons with good communication and information technology skills to market the electronic library software product. The plan would also include the strategy on how to identify potential institutions and organizations that are currently in need of the product to improve education sector that would include private and public education institutions and organizations. Once this planning is complete and deployment readiness determined, the deployment phase process plan is then executed.

e) **Maintenance**

The maintenance of the software involves identification of the faults in the software and modifying the software after it has been deployed. Since the software would have been prepared without the input of all stakeholders, the maintenance process is inevitable and the faults may either result from the design or interference with other existing software and hardware. In the developed electronic library system, the maintenance would be a continuous process and will be an iterative process where the design may be modified or the requirements and specification revisited to correct anomalies that might interfere and lead to poor performance of the product.

5.2. Conclusion

In this research project we have been able to show how the electronic library system can be used to manage the library services in academic institutions and organizations. In particular we have designed and developed an electronic library system prototype that could be used in improving and managing library records and services. The prototype designed, developed and implemented would manage the following operations and tasks;

a) Allow registration of members who seek library services in approved education institutions.

b) Able to manage books and fine payments records.

c) Allow members to make or cancel appointments, that is, they conveniently arrange to visit the library for service at a convenient and appropriate time, services that are not incorporated in the components of the current electronic library systems and therefore not available.

d) Allow connection to commercial banks institution to access credit for payment of fine and lost books payments.

5.3. Further Research

In advancement of technology we propose to have the following technology incorporated in future library systems;
a) The members would access library services from the hand-held portable electronic devices.
b) The library services would be available 24/7 at the convenience of users at an affordable cost.
c) All library services would be integrated and the members would therefore access any library for service that includes accessing eBooks, journals and digital materials at an affordable cost.

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