Algorithmic Relational Design Model For Online Library Information Retrieval System

Alade, O. A., Adewale O. S, Ojokoh B. A.

Abstract— Institutional library is a major infrastructure in any institution of learning. The quality of professionals produced in our institutions, to a greater extent, depends on the access of staff and students to foundational, fundamental and current literatures. In most institution of learning today, more money are being pumped in the school learning but less patron attend the institution libraries. This is due to the fact local and regional library are not accessible online to the target audience. There is therefore a need to harmonise the institutions' library collections and the digital resource of local and regional libraries in order to make the collections visible to the local and global patrons. This can be achieved by developing and implementation of an efficient web enable application base on a methodical mathematical relational model as an engine to access these materials. In this paper, the basic operations of library system was explored and a mathematical relational model is proposed for information capture, patrons' tracking, circulation operations and information retrieval systems thus An web enabled application was developed to test the efficiency of every facet of the model. The system was designed to offer accessibilities to other institutions' libraries globally and vice versa based on mutual understanding. The proposed system offers a dynamics to information retrieval system in that is diverges from retrieval system from a particular application point of view as obtained in many other models. It ensures optimal operations of the library services.

Index Terms— digital library, information retrieval model, library patrons, relational model, search engine.

1 Introduction

Alibrary is an organized collection of sources of information and similar resources, made accessible to a defined community for reference or borrowing. It provides physical or digital access to material, and may be a physical building or room, or a virtual space, or both.[13]. A library is regarded as the repository store of knowledge; the collection of books (both reference and general) technical reports, periodicals, collection of magazines, journals, conference proceedings and the like make a library [4], [1]. [12] highlighted the two important roles of libraries as - repositories of knowledge and keepers of culture. Library is a communication system whose primary function is to preserve, transmit, and increase human knowledge [3] The purpose of a library is to promote reading and love of literature; maintenance of a collection of excellent quality materials supporting a wide range of interests and abilities, accessible to students, faculty, and educated society; uses and teaches the use of technology which is infused into and supports a curriculum in which every student is able to access, evaluate and use information, and uses well-developed creative and critical thinking skills; and in which every student develops into an information-literate person, a lifelong learner, and a responsible citizen [4].

- *Adewale, O. S., Department of Computer Science. Federal University of Technology, Akure, Ondo State, Nigeria (E-mail: adewa.le@futa.edu.ng) .*
- *Ojokoh., B. A., Department of Computer Science, Federal University of Technology, Akure, Ondo State, Nigeria (E-mail: bolanleojokoh@yahoo.com)*
- *Alade O. A., Department of Computer Science, Federal Polytechnic, Bida, Niger State, Nigeria (E-mail: kaleabel@gmail.com) .*

It helps to develop peoples' knowledge in a particular area of interest or for general information. The librarians are charged with the responsibilities to acquire, index, and present the library collections in a way that will make it readily available for the users. It is observed that with the invention of printing machine in the 15th century and an expanded economy, books became more readily available and reading increases [9]. The library operations became more increasingly complex. Libraries can be classified as National libraries, Research Libraries or Reference Libraries, Academic Libraries, Public Libraries, and Special libraries. [9], [12]. According to [10], "Given the limited funding to academic libraries in Nigeria, it is obvious that students and scholars can only access a small portion of the information available in their disciplines. Thus, with the escalating cost of information materials and dwindling allocation of funds to academic institutions, a judicious balance must be made to ensure that users of the academic libraries in Nigeria have access to relevant and appropriate information in their fields of interest. This can only be possible if libraries lay more emphasis on access rather than ownership. Basic tasks in library management include the planning of acquisitions, library classification of acquired materials, preservation of materials, patron borrowing of materials, and developing and administering library computer systems. More long-term issues include the planning of the construction of new libraries or extensions to existing ones, and the development and implementation of outreach services and reading-enhancement services Before the computer age, this was accomplished by the card catalog — a cabinet containing many drawers filled with index cards that identified books and other materials. In a large library, the card catalog often filled a large room. Library automation witnessed a great improvement with the advent of the 4GL in the development of local databases for information storage and retrieval on microcomputers. The explosive growth of the Internet and continued proliferation of electronic information resources place libraries in the middle of revolutionary changes in the way the information is stored and accessed [2]. The emergence of the Internet, however, has led to the adoption of electronic catalog databases (often referred to as "webcats" or "online public access catalog" OPACs), which allow users to search the library's holdings from any location with Internet access [12]. The introduction of the

intranet/Internet resource centres in many higher institutions of learning in the country is a great drive to lunch into the cyberspace to present in-house library collections to the outside world, as well as tapping from virtually unlimited library resources, and to collaborate with other local and international libraries. In today's world, a library's presence on the Web ranks only slightly behind its building in shaping its users' impressions [3]. A way to achieving this is provision of remote access to collections regardless of location of the information source through a well designed information retrieval model. There is also an added advantage of speed of service. Since information is electronically available, retrieval is instantaneous, hence the need for an efficient model to access these collections A digital library is viewed by [7] as a library whose collections consist of digital objects. According to [6], it is an assemblage of digital computing, storage, and communications accessories needed to reproduce, emulate, and extend the services provided by conventional libraries such as collecting, cataloguing, searching, and disseminating information. A full service digital library must accomplish all essential services of traditional libraries, and also exploit the well-known advantages of digital storage, searching, and communication. [5] defines digital library as organizations that provide the resources, including the specialized staff to select, structure, offer intellectual access to, interpret, distribute, preserve the integrity of, and ensure the persistence over time of collections of digital works so that they are readily and economically available for use by a defined community or set of communities. [14] describes a digital library as focusing on audience and understanding, and contains resources that allow users to find needed content; and places that content in digital perspective via linkage to other content. In a better world, high-quality, peer-reviewed information would be available soon after its creation. It should be easy to find, and it should be available long after its creation, at a stable address, in a stable form. This could be achieved only through digital library [8]. To do this, libraries would have to mount and maintain digital object repositories. The emergence of web-scale discovery layers refreshed the way in which discovery is conceived and presented to library patrons and implementation has consumed a degree of academic library energy in recent years. Towards the end of the decade a new trend emerged with next generation library systems being developed by a number of vendors, some not traditionally active in this space, including open source developments. [11]. Some of these are not properly developed and therefore inefficient. Some models has been employed over the years to model information retrieval. Some of them are Information retrieval (IR), Inverted files, Boolean model Vector, Probabilistic and Ranking models etc. Detail information of these model and their deficiencies are discussed in [15], [16]

2 Research Methodology

2.1 Basic Library Operations

The basic operations of institutional libraries were observed to consist of (i) public services, and (ii) technical services. Public services consists of material selection, circulation of library materials, inter-library operations, use of collection catalogue, reference services; while technical services include acquisition of library materials, catalogue of materials, and preparation of materials for placement in the collection.

2.2 Design Structure

The goal of this design is to propose a mathematical relational model based on the major activities of a typical library. The structural view of the design is based on three tier level architecture [1] as shown in figure Figure 1 below.

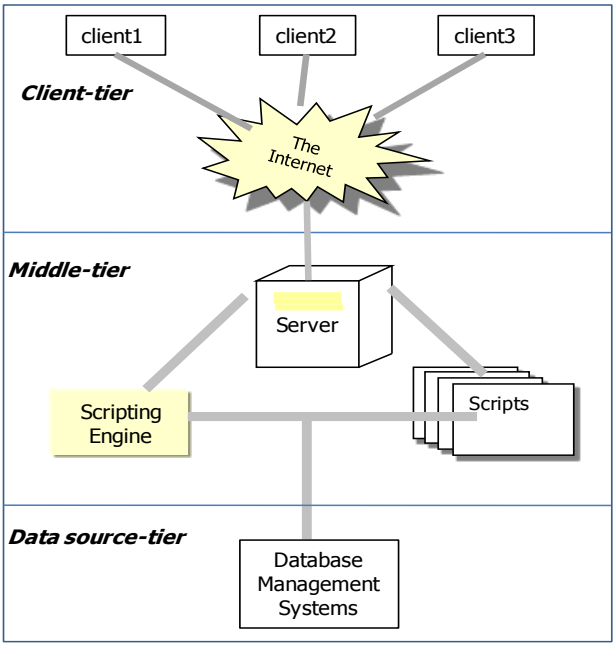

Figure 1: System model architecture

On the top of the structure is the *client-tier.* The client-tier of the application is typically optimized for user interaction. The interface is based on HTML, that enables the web browser (Internet Explorer in this system) interacts with the application at the client side. HTML was used to define the format and style of the web pages and presenting information using the web browser. The *middle-tier* is a complex level that contains most application logic that communicates data between other levels of the system. The web server used was the Internet Information Server (IIS). IIS is used to achieve a secure client-server communication that is, pre-processing of requests and post-processing of responses, permitting site-specific handling of HTTP requests and responses. Active Server Page (ASP) is a scripting language used to communicate with the database. The *data source-tier* is the database management system (DBMS) – the back engine of the system resident on the server – used to create, delete, modify and query the data contents of the database. The architecture of the system is based on the following software suites: - a browser, Hypertext Markup Language, Hypertext Transfer Protocol (HTTP) and Transmission Control Protocol/Internet Protocol (TCP/IP). HTML delivers and displays information using a web browser application, TCP/IP transfers data between application over the Internet, and HTTP interfaces the database to the web. The tools and specifications for the Online Library are described below.

2.3 Design Algorithm

- Define library services
- Create databases for the services defined
- Capture data into the relations (books, journals,

articles, audiovisuals etc)
- Define patrons and their privileges
- Formulate the search engine
- Define and manage patrons/contents interactions
- Generate reports.

2.4 Mathematical Model for the System

Define library services = *F*(Table, Cap, P, S, C) (2.1)
where Table = data container for library items, Cap = addition/update of library items, P=patrons; S = search; C = circulation
To capture data into the database Tables

$$\text{Cap} = G(\text{Table}(x_{ij}), id_i) \quad (2.2)$$
$$\text{Cap} = G(\text{Table}(x_{ij}), x_{ij} = b_i)$$

where x_{ij} = entries to tables, id_i = valid identification of a privilege library staff ($x_i = x_1, x_2, x_3, x_4, x_5$) = books, journals, articles, projects, audiovisuals respectively Patrons

Patron = $K(P_{ij}, n, t, id_i)$

where P_i = patrons' entries, n = maximum number of items holding, t = maximum loan period (in days), id_i = library staff id

$$P = \begin{cases} \text{Table}(P_{ij}),\ P_{ij}(\text{status}) = \text{staff}, \text{set } n = 4, t = 90 \\ \text{Table}(P_{ij}),\ P_{ij}(\text{status}) = \text{students}, \text{set } n = 2, t = 14 \end{cases} \quad (2.3)$$

Search

$$S = N(\text{Table}(x_{ij}), x_{ij} = b_i)$$

$$\begin{cases} search(\text{Table}(x_{ij}), x_i = \text{books}), \text{search is based on } x_{ij} = \text{title}, x_{ij} = \text{author}, x_{ij} = \text{classification} \\ search(\text{Table}(x_{ij}), x_i = \text{journals}), \text{search is based on } x_{ij} = \text{title}, x_{ij} = \text{classification} \\ search(\text{Table}(x_{ij}), x_i = \text{articles}), \text{search is based on } x_{ij} = \text{title}, x_{ij} = \text{author}, x_{ij} = \text{discription} \\ search(\text{Table}(x_{ij}), x_i = \text{projects}), \text{search is based on } x_{ij} = \text{title}, x_{ij} = \text{author} \\ search(\text{Table}(x_{ij}), x_i = \text{audiovisuals}), \text{search is based on } x_{ij} = \text{label}, x_{ij} = \text{description} \end{cases} \quad (3.4)$$

Circulation
Circulation = $C(loan(x_{ij}), return(x_{ij}), P_i, id_i)$ (2.5)

define z_i = no-of-item(s) holding by patron P_i, where P_i = Patron id and id_i = library staff id

Loan = $loan(x_{ij}, P_i, id_i)$ (2.6)

for valid id_i, if P_i exists,

P_i(staff) and $z_i < 4$ where $item_i = \text{Table}(x_{ij})$,
set $\text{Table}(x_{ij}) = item_i(\text{available}) = \text{false}$
P_i(students) and $z_i < 2$ where $item_i = \text{Table}(x_{ij})$,
set $\text{Table}(x_{ij}) = item_i(\text{available}) = \text{false}$

R = $return(\text{Table}(x_{ij}), item_i, id_i)$ (2.7)

for valid id_i where $item_i = \text{Table}(x_{ij})$,
set $\text{Table}(x_{ij}) = item_i(\text{available}) = \text{true}$

3.0 Analysis of the System Model

The proposed design was to ensure efficiency of management library collections, that is data capture, patron registration and usage, search and circulation as shown in equation 2.1. The database objects were conceptualised using relational database model as shown in equation 2.2. The general form of a relation is given by:

$$R[a_1, a_2, \ldots, a_n]:$$

where R is the relation and a1, a2, …, an represent the attributes of the relation R. The Library (refers to as the System) has a database as back engine. The database is called **LibraryData.** It contains the **books**, **journals**, **articles**, **projects** and **audiovisuals** objects defined in equation 2.2. More so, patrons' entries and other relevant operational parameters are held in $\text{Table}(P_{ij})$ represented in equation 2.3. The relations used in the system design are represented below:

books[*bookid, classification, title, author, isbn, edition, year, publisher, place, available*]

journals[*journalid, classification, vol_no, isbn, publisher, year, place, title, available*]

articles[*articleid, title, author ,page, journalid, description*]

projects[*thesisid, title, author, year, department, supervisor, diploma, matricno, available*]

audiovisuals[*avid, label, author, version, year, description, available*]

patrons[*userid, firstname, middlename, lastname, address, phonenumber, picture*]
loantable[*materialid, type, userid, dateborrowed, returndate*]

Database Design Description

The structures of the relations in **LibraryData** database describe above form the underline data source of information need for library management and dynamic virtual access to the library contents. The design of the relations and the associated operating procedures are described below:

Books relation: -
Books [*bookid, classification, title, author, isbn, edition, year, publisher, place, description, available*]
has eleven attributes. Three of these are most useful for library search. These fields are *title, author and classification* (equation 2.4). Others provide detailed information about each book. *bookid* is a unique field that contains the book ascension number in the library.

Classification: assists both the patrons and library staff to locate the position of a book on the shelf. *Available* field inform the patron if the intended book is in the library or not. The field specifies **true** if the book is available, and **false** if it is on loan (see equations 2.6 and 2.7). Quite a number of object modules use the **books** relation. Some of these are *addbook.asp, Library_admin.asp, updatebook.asp, loanout.asp and delete.asp.* All the fields in the **books** relation are required.

Journal relation: -
journals[*journalid, call_no, vol_no, isbn, publisher, year, desription, place, title, available*] contains ten fields as shown above. As in **books** relation, *title* and *classification* are fields

used for search (equation 3.4). Others provide detailed information about each journal. *search.asp, delete.asp, addjournal.asp, editjournal.asp, library_admin.asp and updatejournal.asp* are routines for searching and various library management operations.

Articles relation: -
articles[*articlesid, title, author, page, journalsid, description*]. A relationship is enforced on **journals** and **articles** relations by a foreign key – *journalsid.* This allows each article to link to its respective journal. *articlesid* is the primary key that uniquely identifies each article in the relation.

More so, *search.asp, addArticle.asp, Listarticle.asp, updatearticle.asp* and *delete.asp*. are the library search and management routines that operate the relation using equation 3.4 and 3.2 of the model

Audiovisual relation: -
audiovisual[*avid, Label, Author, Version, Year, Description, Available*] has seven attributes as shown. Materials can be added/updated, searched (equations 3.1 and 3.4) and deleted. Materials in the relation can be loaned and returned (equations 3.5, 3.6 and 3.7); they can also be manipulated for various library operations using *addaudiovisual.asp, updateaudiovisual.asp, searc.asp, loanout.asp and delete.asp* routines.

Patrons relation: -
patrons[*userid, firstname, middlename, lastname, address, phonenumber, picture*]

contains seven fields. The relation is managed by the following routines: *register.asp, loan.htm,* and *loanout.asp* to register library users and monitor their borrowing activities from the library. Patrons are classified into staff or students during registration. Equation 3.3 and 3.6 reflects the rights and privileges of the patrons depending on their status

Loantable relation: -
loantable[*materialid, type, userid, dateborrowed, returndate*] has five fields. The fields are internally operated by other routines any time a loan transaction is carried out (see equation 3.6).

3.1 Scalability and performance advantages

To deal with the increase in concurrent users (Big Users) and the amount of data (Big Data), applications and their underlying databases need to scale using one of two choices: scale up or scale out. Scaling up implies a centralized approach that relies on bigger and bigger servers.

4.0 Conclusion

This paper has discussed the general importance of library to the literate community. Different views of researchers on the subject of library were reviewed. Various activities of the librarians to prepare the library contents ready and available to users was discussed. The developments in the use of library and its use was reviewed. The contributions of researchers to assist the librarians in their library activities and presentation of library contents to the patron were also discussed. More so, the interaction of librarians/clients with library collections was conceptualised on 3- tier system model architecture – client, middle and data source tiers model. The interaction on the architecture was translated into mathematically models for efficient operation of the librarians and easy access of patrons to library collections. We propose improved model digitization of local library collections and their international registration using Digital Object Identifier (DOI) for global access as area of further research .

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