Consolidation of School E-Libraries Database Using Multitenancy Approach

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ABSTRACT

School Libraries exist to support teaching, learning and research needs of their parent institutions. This is done through the provision of up to date information resources to their users. Librarians and researchers are in search for new ways of serving their users more efficiently and effectively. In this work, we present a multi-tenant library architecture which consolidates multiple databases to improve access to library information resources and effective utilization of database serves thereby reducing the implementation and operational cost of a school library.

Keywords - Multi-tenancy, Tenant, Database, Server, Library.

1. INTRODUCTION

Societies all over the world have used education as an instrument for the achievement of their national interests and objectives. Education fosters the worth and the development of the individual, for the individual's sake and for the general development of the society [1]. A Library is an establishment charged with the responsibility of collecting information resources and making them accessible to those who require them [2]. Libraries provide resources for knowledge acquisition, recreation, personal interests and interpersonal relationships for all categories of users [3]. In an academic library, attention is focused not only on the students and researchers, but also on the library staffs who continue to strive to collect, store, organize and disseminate all forms of recorded knowledge in order to satisfy both present and future information needs of users [2].

A library has also been defined as an institution that manages the intellectual products that individual can gain access to readily [4]. The library can also be seen as an instructional and self-development Centre, which operate as an integral part of the entire school environment [5]. The library information resources have been defined as those information bearing material both in printed and electronic formats, such as textbooks, journals, indexes, abstracts, newspapers, magazines, reports, CD-ROM databases, internet/E-mail, video tapes/cassettes, diskettes, magnetic disk, computers and micro films, which make library services possible [3]. A library database is a collection of information resources that is organized in a way that it can be easily access, manages and updated when needed.

However, gaps such as difficulty in locating and accessing the needed information from multiple databases still remain relative to the potential of more universal access to the universe of content of interest to libraries and their users. This impedes library progress that this research wants to address. As innovation and creativity continues, software developers continue to build applications that require new ways of accessing and manipulating data. The field of information management has had its fair share of this dynamism leading to the exposure of limitations, such as difficulty in locating and accessing the library information in an institution. This limitation can be greatly improved by consolidating the library system. Consolidation of multiple databases can be done using the concept of multi-tenancy.

2. RELATED WORKS

Digital libraries are relatively new, evolving increasingly with the phenomenal success of the internet. This has opened up the idea that digital collections can be made available to a wide variety of users over an international platform. With this innovation comes a limitless set of problems to be overcome through research [6]. In this review, the broad outline of the types of problems facing digital library development will be discussed resulting in particular focus on accessibility, utilization and cost. Ultimately, these shortcomings are investigated through discussion of research into proposed architecture for consolidating multiple databases in order to begin to create some standards for digital library development. This literature also shows that librarians have shown great concern over the availability of electronic resources for academic purposes and factors affecting their effective utilization.

2.1 University Library

According to [7], a university is a citadel of learning and research. A university library is regarded as a repository of knowledge and information gateway where various information materials are stored. [8] pointed out that university libraries are set up to assist the execution of their statutory duties. University libraries are the centre of both learning and research activities in the universities. One of the objectives of university libraries in Nigeria is to develop and maintain collections in all formats –print and electronic and to make these information resources available and accessible to all users [7]. It is pertinent, therefore, that academic libraries should facilitate uninterrupted access to scholarly electronic publications to meet users' resource needs. [9] observed that the central purpose of libraries is to provide service access to information, while modern information and communication technologies are making it possible for libraries to provide a variety of library and information services to their users.

2..2 The Emergence Of Electronic Library System

The emergence of ICT has affected the role and services of the academic libraries. As [10] noted, the rapid pace of development in the field of IT and the emergence of networked information services have prompted a comprehensive review of the library and information science profession. There is a clear paradigm shift from manual ways of carrying out information services powered by analog data to electronic ways of accessing and retrieving information powered by electronic gadgets. ICT according to [11] is being introduced and included into all aspects of library services.

E-library and e-resources are becoming the order of the day in library and information practice. In a nutshell, the libraries especially the academic libraries have to adapt to the e-environment in line with the indications of [12]. For the university library to be where their users are, they have to fully recognize the fact that the world is living in virtual realities as was indicated by [13] where library services are in cyberspace and are not affected by opening and closing hours. Users of academic libraries now expect to be given what they need, when they need it and from which ever location they may be [14]. University libraries are now expected to provide to users a range of information and communication technologies and e-resources necessary for retrieving information quickly from both immediate and remote databases, as well as creating a need for library cooperation and consortium initiatives [15]. Achieving 'education for all initiative' in Nigeria will be much more attainable when sound library and information services are provided in different institutions especially electronically. Through e-resources, education can get to people from physical as well as remote locations.

2.3 The Place of Electronic Resources In the Attainment of School Libraries' Objectives

Electronic resources have boosted the collection of libraries worldwide by digitizing ageing collections which has raised the hope of meeting the user information needs and automated operations. As a result of serious economic downturn in Nigeria from the 1990s, most university libraries in the country had difficulty in acquiring recent journals and other publications to meet the user needs for teaching, learning, research and community service [7]. With the increasing availability of electronic resources, the users would have better quality collection and that would enable them appraise their collections effortlessly and to assess the value of expensive journals and databases both within and outside the library. [16] asserts that traditional libraries stored different types of information resources in different formats in their buildings. Various tools and guides to locate these resources were available only when a patron physically visited the library. The situation has now changed and access to these guides has become paramount. He concludes that with the advent of computers and telecommunication technologies, libraries and information centres can provide access to these resources through workstations within the library building. The impact of using electronic resources is very significant. This is simply because it supports high quality information service network which provides access to full range of learning and teaching materials in various formats [17].

The need to have ready access to relevant information for improving knowledge is of strategic importance to the society [18]. The introduction of electronic information sources into academic environments, particularly universities, is almost predictably followed by rapid growth in awareness and use of the resources by students and academics [19].

## 2.4 Problems Faced by Nigerian School Libraries

A good number of factors hinder the adequate provision of library and information services and resources by school libraries. One obstacle to the use of a library's resources and in particular, an electronic resource is that they are not seen as being easily accessible [7]. This is in contrast to an Internet search engine where a single keyword search could result in thousands of hits, no matter the topic. In the library, students have to choose a particular database and be more selective in the search words they use [20]. [21] examined some of the barriers to the use of electronic resources available at the medical library of the College of Medicine, University of Nigeria, Nsukka. Their findings revealed that lack of an adequate ICT infrastructure and affordable online access, absence of in-depth ICT skills and information searching skills among library staff and users are barriers to the use of electronic resources. In the same vein, [22, 23, 24, 25] identified problems in the adoption and usage of ICT and electronic resources in Nigeria to include lack of adequate ICT skills among staff and users, low basic information literacy levels in the Nigerian population and prohibitive cost in developing countries to gain access to the Internet.

The findings were corroborated by those of [26] who studied Internet access and use by the students of private universities in Ogun State, Nigeria. For university libraries to meet the expectations of their users and the current wave of technological developments in the library and information services which can facilitate their contribution to achieving education for all, improved funding is needed [27]. Many other improvement strategies emanate from this; like automation, acquisition, installation and utilization of electronic resources and facilities including subscribing to and maintenance of access to databases in different disciplines as well as training and re-training of users will all be facilitated when funding is adequately available. Therefore, considering the low utilization of information resources and as well as the need to reduce hardware and operational cost which is associated with the current library system, it is more reasonable to adopt a multi-tenant database (MTD) in the school library.

2.5 Multi-Tenant Achitecture

Software as a Service (SaaS) constitutes a fast-growing business model for the sales of software that is based on the principle of outsourcing. With Software as a Service, a service provider hosts an application or software on its infrastructure and delivers it as a service to several tenants. According to [28], A Multi-Tenant Database (MTD) is a way of deploying a Database as a Service (DaaS). It refers to a principle where a single instance of a Database Management System (DBMS) runs on a server, serving multiple clients (tenants) as depicted in figure 1. These tenants subscribe for the service and access it across the Internet through standard web technology [29]. In the same way, general services and DBMS service can also be out sourced for some reasons that are obvious to the tenants.

The concept of Container Databases (CDBs) and Pluggable Databases (PDBs) is a new concept, and is fundamental to providing the 'missing link' in database consolidation for libraries [30]. A CDB can contain one or more PDB, and a PDB is the actual 'database' from the viewpoint of the application. PDBs can be plugged into and unplugged from CDBs using simple commands, and they can be cloned and moved to other CDBs. All the PDBs that are plugged into a CDB share a single instance and can be resource-managed by a single set of controls within the CDB.
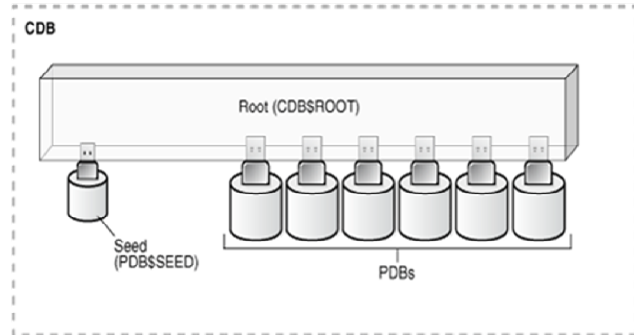
Figure 1: Multitenant Architecture (Oracle Corporation, 2013).

2.6 Approaches To Managing Multi-Tenant Data

The typical character of Software as a Service applications is 'single-instance multi-tenancy', according to this feature, three main approaches have been proposed: Separate database, Shared Database with Separate Schemas and Shared Database with Shared Schemas [31]. Of the three approaches, the shared schema approach has the lowest hardware and backup costs because it allows you to serve the largest number of tenants per database server. However, because multiple tenants share the same database tables, this approach may incur additional development effort in the area of security, to ensure that tenants can never access other tenants' data, even in the event of unexpected bugs or attacks. The shared-schema approach is appropriate when it is important that the application be capable of serving a large number of tenants with a small number of servers, and prospective customers are willing to surrender data isolation in exchange for the lower costs that this approach makes possible.

2.7 Factors Influencing The Choice Of Multi-Tenant Database Approaches

There are factors that help in determining the most suitable and appropriate approach of multitenant database. The use of the system should be one of the influencing factors towards the decision. [32] emphasize that the tenant application and usage requirements should be the primary consideration in deciding the right model of multi-tenant database. Sometimes users (tenants) are not equipped with necessary information about this before taking decision on what approach to adopt. Their decision is sometimes influenced by what vendors tell them. There is need to examine all these basic factors before approaching a service provider in order to make the right decision on this. Some of these factors are itemized by [33] are Size of tenant database, Number of tenants, Number of users per tenant, Growth rate of tenants, Growth rate of tenant database, Security, Cost and Flexibility – ability to create multiple tables by tenants. All these are major consideration that must be considered to make a good decision about the adoption of a multi-tenant database model depending on the tenant individual system requirements.

3. ANALYSIS OF THE EXISTING SYSTEM

Rapid advances in information technologies have revolutionized the role of libraries. As a result, libraries face new challenges, competitions, demands, and expectations. Libraries are redesigning services and information products to add value to their services and to satisfy the changing information needs of the user community. Traditional libraries are still handling largely printed materials that are expensive and bulky. Information seekers are no longer satisfied with only printed materials. They want to supplement the printed information with more dynamic electronic resources as demands for digital information are increasing [34].

Many academic libraries are actively involved in building institutional repositories of the institution's books, papers, thesis, and other works which can be digitized or were 'created digital'. Many of these repositories are made available to the general public with few restrictions, in accordance with the goals of open access, in contrast to the publication of research in commercial journals, where the publishers often limit access rights [35].

Many Institutions encourage their enterprise units (divisions, departments, and libraries) to be independent from each other. These enterprises' databases are deployed on dedicated servers, which are not fully utilized during much of the time. These days, there are a lot of databases scattered over many machines, within the same institution with reasonably large size. The needed information to run a modern library is scattered across multiple isolated information islands in a sea of computers and database systems. As a result, the information users do not know what data are available in each database. They do not know where to find data that they believe are available. This situation makes it difficult, if not impossible, for users to access information when needed.

This current library structure contributes to the increase of Islands of Unreachability, of which many Users cannot access these islands of information, as well as leads to low utilization of dedicated servers. Although the advent of ICT has affected the role and services of libraries, it has also brought about some revolutionaries in the library as well as the school library. In fact, according to [10], the rapid pace of development in the field of Information Technology (IT) and the emergence of networked information services have prompted a comprehensive review of the library; specifically the school library and information science profession. While the developed countries are far ahead, the developing countries including Nigeria is behind with much more work to revolutionize the school libraries in Nigeria.

3.1 Issues And Challenges of the EXISTING system

In recent times, the volume of information created, generated and stored are immense that without adequate knowledge of information retrieval methods, the retrieval process becomes cumbersome and frustrating for the user. Studies have shown that information management is essential in a school library for storage and retrieval of information. These days however, it is fairly common to find hundreds, or thousands of databases scattered over many machines within an institution with reasonably large size. The needed information to run a modern library is spread across multiple isolated information islands in a pool of computers and database systems, which is susceptible to: difficulty in locating and accessing these Information Island; low utilization of these dedicated database servers and high implementation cost associated with this model of database deployment. As a result, the following problems still exist in the school library: Wastage of Resources, Islands of Unreachability (IOU) Problem and High Implementation Cost.

4. THE PROPOSED SYSTEM

Based on the issues associated with the current digital library system, Multitenant Library Architecture (MLA) is proposed. This new architecture is adopted because it provides flexibility to help meet demanding and evolving library needs. The multitenant architecture enables a database to function as a multitenant Container Database (CDB) that includes zero, one, or many user-created Pluggable Databases (PDBs). A PDB is a portable collection of schemas, schema objects, and non-schema objects that appears as a non-CDB. The Multitenant Option of the Library Database is implemented through the concept of Pluggable Databases (PDBs). A PDB is essentially the same as what we have always used in the past, with all the generic data dictionary information removed. These PDBs cannot execute by themselves, they need to be plugged into a Container Database (CDB), which contains all the data dictionary information that is absent from the PDB. A CDB can host multiple PDBs, and so allows a single set of data dictionary information, background processes and memory allocation to be shared across multiple PDBs.

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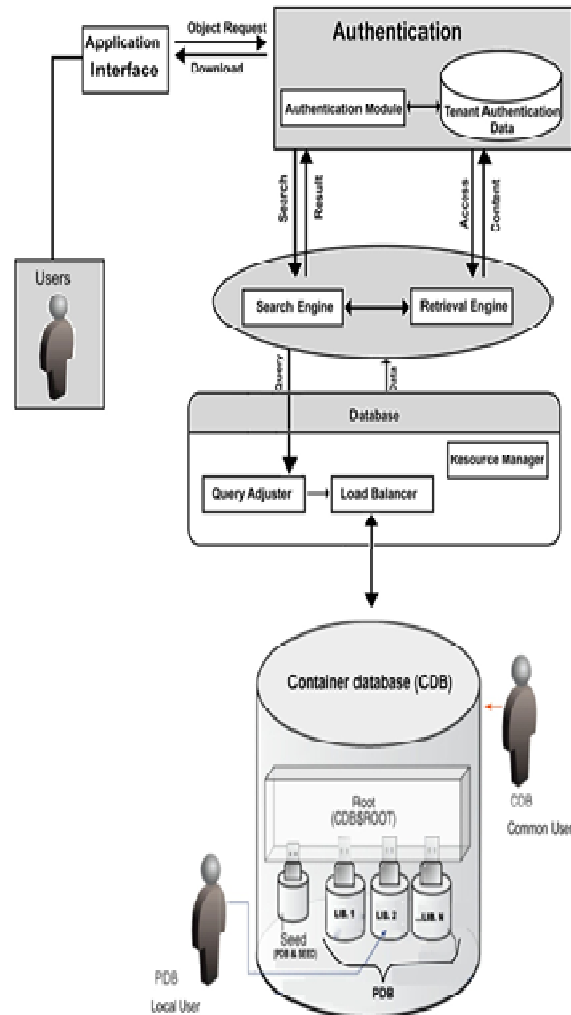
Figure 2: The Multi-tenant library architecture

Figure 2 shows the proposed multi-tenant library architecture which is based on a number of components; an authentication module, a distributed search engine and retrieval engine, the system data repositories and the user interface module.

Authentication Module
The authentication module is responsible for identifying users and verifying that users are who they claim to be and are permitted to perform each request by providing answers to some set of questions or better still use a password.

Search and Retrival Engine
The search engine implements a distributed search of metadata regarding the system repositories. The output of search queries provides metadata information about available information, programs and images and a link of their location. The user browse metadata information then selects a link of interest and queries it via the retrieval engine.

The retrieval engine offers two main functionalities. First, it enables the access of data content that reside in multitenant databases through the application interface (other interfaces such as FTP and HTTP are also supported). In accordance with this interface, the retrieval engine supports a restricted SQL query language to query the data.

Query Optimizer

To support a distributed access to data, the query has to be transformed in a format supported by the system. A software module, called query adjuster also known as gateway, takes charge of the dynamic translation of the original query into a supported format when queried.

Resource Manager

In a multitenant environment, one concern is contention for system resources among the PDBs running on the same computer. To address such resource contention, usage, and monitoring issues, it is the function of the Database Resource Manager to do so.

Load Balancer

It differs from resource manager in that it distributes workloads across multiple computing resources, such as computers, a computer cluster, and central processing units. It aims at optimizing resources use, maximize throughput, minimize response time, and avoid overload of any single resource.

Container Database

The container database has five containers: the root, the seed, and three Pluggable databases which represent each library database. The root is a collection of schemas, schema objects and non-schema objects to which all pluggable databases belong. Every container database has only one root which is required to manage all pluggable databases. Pluggable database is a user created set of schemas and objects that appears as a non-CDB. Each pluggable database has its own dedicated applications. The Seed is a template for creating new PDBs. So when queried, the system searches the entire PDBs to locate the required information. This system saves time and eases procurement process.

5. CONTRIBUTIONS TO KNOWLEDGE

This research has exposed the limitations of the current library system. It has also proffer solutions to the problems of Islands of Unreachability (IOU); high operational cost and resources wastage as well as proffer solutions with the introduction of a Multi-tenant library architecture. The research serves as a guide to database administrators and developers to decide on the architecture to employ in projects involving databases.

6. CONCLUSION

Consolidation of school library system using the concept of multi-tenancy can lead to easier management and monitoring of the physical database, improve efficient utilization of dedicated servers, reduce the operational cost and improve greater access to larger pool of information resources. Thus this dynamic approach introduced will help reduce the high computational overhead from the numerous separate databases involved as well as reduce the time spent. The library user can access data from one physical database (one set of files and one set of database instances) rather than split attention among dozens or hundreds of non-CDBs. Backup strategies and disaster recovery are simplified. Administrators and developers should consider carefully which type of database best suit their needs before committing to one implementation or the other as the wrong choice could have side effect.

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