Journal of Innovative Technology Convergence
Vol. 3, No. 1 June 2021, pp. 23-34

A Study of the Concepts and Design of Library Cloud with Security Features

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Abstract: The digitization of Library resources has been increasingly evolving as the Internet has taken over as the major means of communications and delivery of information. There has been an emerging proliferation of e-library services that has brought library resources to students and academicians prominent access. This paper deals with the analysis of the concepts and design of Library Cloud with security features to effectively provide library resources to academic institutions. It aims to design a Library Cloud which will be the consortium of various digital Libraries of different universities and academic institutions. It takes full advantage of the features of Cloud computing in order to optimize the provision of such library resources. The security features will be defined to provide the basis for the development of Library Cloud and its services.

Keywords: Information security, Cloud computing, Library Cloud, security features

1. Introduction

Cloud computing emerged as one of the new paradigms in computing that is expected to deliver computing as a service. Cloud services are expected to be marketed just like the daily utilities and clients will only be charged with the utilized services suited for their needs. Hardware virtualization has aided cloud services to be hosted in client environments based on their usage variants [1]. The virtual hardware can provide services to multiple clients. The sharing of resources among several users results in a decreased usage cost. This allows cloud service providers to market the resources at acceptable rates which are lower than the outright purchase cost. The provision and accessing of resources through services is in total contrast with outright purchasing or leasing of resources from data centers [2]. The resources being leased or purchased are dedicated for either a single or few clients irrespective of their

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Received [November 26, 2021]; Revised [February 8, 2021]; Accepted [April 25, 2021]

Published by InnoCon Publishing
ISSN 2704-4440

usage forcing clients to pay a constant amount and unaligned charges rather than paying only for what they need and have utilized.

Cloud providers have emerged several services which are based on user application aside from Infrastructure as a Service (IaaS), Platform as a Service (PaaS), and Software as a Service (SaaS). Initially, Cloud providers have started their business with only three services. As the application needs of users increasingly become diverse, new Cloud services were established in order to support these demands. In this regard, the developmental concentration will be focused more on computing resources such as processing power, hard drive storage capacity, and database storage rather than only on applications [3]. Virtualization will be the technology base for the identified services referred to as infrastructure support. The PaaS was fixed in supporting complete execution packages which bind with the infrastructure modules. The binding is done through the Application Programming Interface (API) which differentiates both the supported and unsupported vectors that are present between hardware and software [4]. The SaaS, on the other hand, provides a platform for marketing software applications as services over the Internet instead of as products. The implementation of Cloud computing showing how different people irrespective of their locations can access the Cloud through various types of devices running on heterogeneous platforms is depicted in Figure 1.

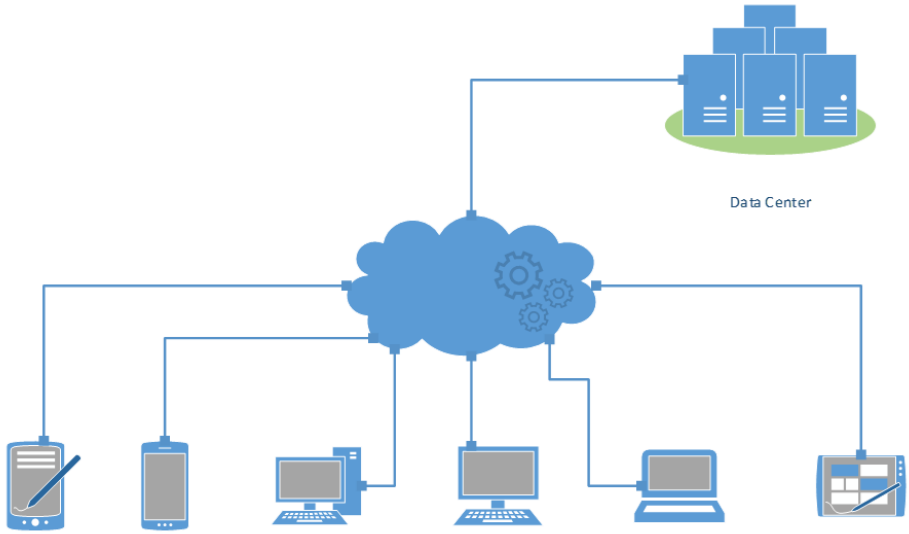

Figure 1. Cloud Computing Platform Connecting Different Devices

There is a vast application area for Cloud computing and can still be further immensely explored to provide fruitful results in more domains. One area in which the concept of Cloud computing can be utilized to provide exceptional results is with the Library services. By definition, a library refers to an organized collection of sources of information and similar resources (*e.g.*, books, periodicals or journals, newspapers, manuscripts, films, maps, and even include resources in digital formats), made accessible to a defined community for reference or borrowing [5]. Libraries provide vast resources of the knowledge thereby aiding in the fields of research and academia cutting across all disciplines of education for Universities and Educational institutions. The resources can be available in many forms such as books, journals, periodicals, newspapers, manuscripts, documents, *etc.* [6].

The academic institutions face a lot of challenges in providing Library services that fulfill the needs of the institutions due to shortage of resources, budget constraints, and other reasons [7]. These shortcomings from the libraries greatly affect the research and academic needs of the affiliated members of the institution [8]. Currently, in the era of digitization, Cloud computing seems to provide the most appropriate solution to these challenges, that is, a Library Cloud wherein Libraries from different

academic institutions can share their resources [9]. The Library Cloud does not only aim to address the issues and challenges concerned but can also provide the benefits offered by Cloud computing itself [8].

The traditional Library services will be transformed through digitization by making all the identified resources available in digital form [6]. The concepts of Cloud computing can be employed in digital Libraries to complete the transformation of the Library experience to a completely different level wherein users can enjoy the advanced features offered by Cloud computing. Library resources offered can be accessed regardless of the user's location without rushing to get through the Library, and it can be read with the user's device at any time. The institution members can access study materials and relevant documents to other disciplines, for example, an engineering student can read books from other fields such as medicine, agriculture, *etc.*, which would not be possible in some cases in an engineering institution.

This paper aims to design a Library Cloud that will act as a consortium of various digital libraries of different universities and academic institutions. The security features for the implementation of this Library Cloud will be analyzed. The Library Cloud will be a great help in saving resources of the involved libraries sharing information amongst the concerned institution members which would not be feasible individually.

The rest of this paper is organized as follows: Section 2 outlines the related works in Cloud computing; the Library Cloud implementation model is outlined in Section 3; the proposed security features are illustrated and discussed in Section 4; the analysis of the advantages and disadvantages of Library Cloud are identified in Section 5; and Section 6 discuss the concluding remarks.

2. Related Works

This section provides a discussion of the existing developments in Library Clouds although it is still a very young concept. Library Cloud have been offered in a variety of ways, and basically the general library experience was transformed into a Cloud experience. The advantages and disadvantages of the identified available services will be discussed and analyzed in detail to become the basis for the enhancement and development of future Library Cloud services.

2.1 The 3M™ Cloud Library

This service is currently operational in the USA and Canada where academic institutions can transform their digital library to the 3M Cloud Library and enjoy the benefits of Cloud computing by accessing it anywhere, anytime, and through any device running on any operating system, such as Android, iOS, or Windows [10].

2.2 Open Library

Open Library is an online project which intends to create one webpage for every book ever published. One can read, buy, or borrow a document for a fee or for free depending upon the document's publisher. The Open Library's book information is usually organized and collected from the Library of Congress, from other Libraries, Amazon.com, as well as from various user contributions through a Wiki-like interface. Links into books are labeled Read, Purchase, or Borrow depending on the availability of the documents [11].

2.3 Google Books

Google Books is a service being offered by Google where a user can search online for books to buy or borrow from the authors or publishers by paying a suitable fee or for free if it is made available in the

public domain [8]. After confirmation from the Google database, Google books were shown in both Google web search and in the dedicated Google Books website. Searches in Google Books result in thousands of related pages available in repositories whenever the copyright owner has given them permission. Books made available in the public domain are available in full view and can also be downloaded for free. For the case of in-print books where permission has been obtained, the number of pages that can be viewed is limited to a preview set by a variety of access restrictions and security measures.

2.4 Library Cloud

Library Cloud is a Harvard Library Cloud Project which is a prototype multi-metadata server that contains fusions of various library metadata from multiple institutions and makes it to be accessible through the open APIs and also as a Linked Open Data (LOD) [12]. Its benefits include an open platform for developers in creating related tools and applications, provision of data for research purposes, and lowering the barriers in creating services for specialized research and teaching communities.

2.5 Analysis of Existing Services

The 3M Cloud Library only provides cloud computing services to the library of a particular institution, while, Open Library and Google Books provide a platform where any e-book or document can be accessed by paying an appropriate fee. Among the identified services, none of them provides a service for free, *i.e.*, there is no possibility of sharing various library resources and serving the greater cause of knowledge sharing amongst members of academic institutions. In addition, there are various restrictions like copyright issues for accessing various documents. There is no platform for sharing documents or thoughts, *i.e.*, no platform for discussion.

3. Library Cloud Implementation Model

The proposed Library Cloud model mainly includes the creation of Cloud which provides the combination of Infrastructure as Service (IaaS), Platform as a Service (PaaS), and Software as a Service (SaaS) [13]. Private Cloud will be utilized, *i.e.*, access would be given only to member academic institutions and their students and other academicians.

The storage services are provided in the form of IaaS for all the resources of the various Libraries in the Cloud. In addition, the Library Cloud provides services in the form of PaaS due to the various applications that need to be developed on the cloud, such as:

- Update of the database upon renting e-books to a member institution;
- Adding and removing resources to and from the Cloud.
- Providing search options in searching various categories of books, journals, and other documents as well as further searching for a specific resource within that category.
- Application that licenses and monitors the status of the borrowed resource from the Library to any e-book reader such as Amazon’s Kindle, and automatically retrieves the borrowed resource upon the expiry of the License.

Moreover, it provides services in the form of SaaS in terms of providing access to the services of Library Cloud applications over the Internet from any Internet-enabled devices.

3.1 Operational Processes of the Library Cloud Model

The entire Library Cloud will be basically managed by a Cloud Service Provider (CSP), either completely dedicated for this purpose or otherwise. Cloud operations will be performed by the CSP including the security features such as Firewall, data protection, and user authentication features. All the member institutions basically need to add their digital Library resources to the Library Cloud and have to adhere to all its rules and regulations. Then, all members of the institution can access accordingly the Library Cloud resources. The details of the operational functions of Library Cloud are discussed below.

1. There would be initially different access levels for the member institutions of the Library Cloud.
2. An academic institution has to invest in the Library Cloud in order to gain membership. The investment can be financially or in terms of resources being brought into the Cloud Library for sharing with other institutions. The level of access can be granted based on these investments of the institutions.
3. The levels of access refer to the amount of resources that can be accessed by the member institution. With the lowest access being granted only to resources concerning a few disciplines and the highest level of access would enable the member institution to have access with all types of resources and concerning all disciplines.
4. In addition, different levels of access are also given to different categories of users within the member institution such as students, teachers, research personnel, and others. These access levels are to be defined by the member institution in the Library Cloud system.
5. The resources can be accessed through search mechanisms once the user has been authenticated and logged into the Library Cloud. The results of the search will depend on the access level enjoyed by the user and the member institution.
6. The user can access his institution's contribution and resources in the Library Cloud without any restriction.
7. The user can then use accordingly the book or the desired resources upon finding.
8. The user can borrow the book for a particular period of time using the Kindle platform [14] or download the resource if it is not protected by copyright laws.

3.2 Borrowing of Books using Kindle Platform

The most common Library transaction in traditional Libraries is usually the borrowing of books or other Library resources. Traditional Libraries may not incur significant issues, but, in a digital library, it is difficult to do a borrowing transaction since copyright issues arise as the e-books and other digital forms of resources are covered by copyright laws, and downloading them would be considered illegal.

This issue can be resolved by the use of e-book readers, and the most popular and the one considered as a pioneer amongst the e-book readers is Amazon's Kindle. Kindle is a popular e-book reader in which people can read, buy and borrow e-books online. This feature of borrowing transactions can be exploited as an advantage in the Library Cloud [15].

Users are permitted to download the e-book or Library resource file using only the Kindle platform. Whenever a user borrows an e-book from the Library, the concerned Library would attach a license with the e-book which contains the details such as the period at which the e-book has been borrowed and the details of the borrower, e-book, and Library. The borrower can no longer read the e-book on the Kindle device upon the expiration of the e-book license, thereby, solving the copyright issues.

3.3 Interaction Platform

A Library is expected to be a place where knowledge is gained and shared for the overall enlightenment of students, researchers, and academicians. That means, the digital version of the Library should also be no different, hence, in the proposed Library Cloud model, an application is developed using the Cloud PaaS feature which serves as an avenue for interaction among the members of Library Cloud discussing relevant topics. Users from different places can discuss with each other concerning research, academics, universities, courses, solve each other's queries, and exchange ideas. Thus, Library Cloud can serve as a powerful tool in knowledge sharing and form the very core principle of Libraries.

People can recommend books for various topics to help out others who do not have an idea about which is the best book for a particular topic. Users are also capable of rating and providing comments on books and other resources after using. Best books can then be categorized on search results based on the ratings.

4. Library Cloud Security Features

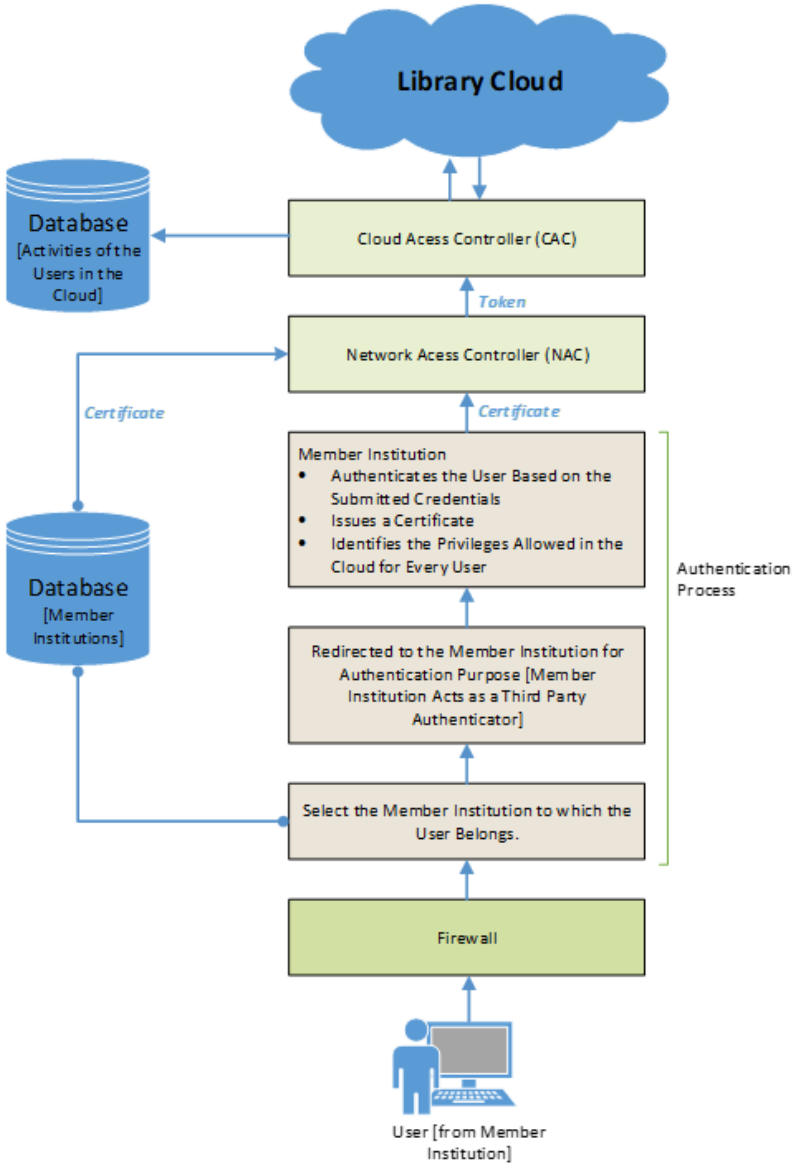

Figure 2. Architecture of the Proposed Library Cloud Model

The vast amount of resources are available in Library Cloud, thus, its protection is of paramount importance. The Cloud is challenged by a variety of attacks and potential threats. In this regard, security measures have been devised in the proposed Library Cloud model. First, an encryption algorithm will be employed on the resources shared by every member institution [16]. This would ensure that Library resources are still protected even if the attackers manage to enter and access the Library Cloud system despite its security features. Secondly, a state-of-the-art firewall protects the Library cloud from intruders [6] and all sorts of external attacks. Finally, Cloud Library's protection can be further guaranteed if only authorized users gain access, thus, a robust authentication scheme is employed to ensure that all users that gained access are certified members only. Figure 2 depicts the architecture of the Library Cloud highlighting the associated security features to prevent unauthorized users from gaining access.

4.1 Security Methodologies

Third-Party Authentication. User authentication into the Library Cloud system is done by an external mechanism or by an external agent. Basically, the third party confirms the identity of the user and sends the authenticity of the user to the requesting server. In the proposed model, the member institutions act as the third party and they verify the users gaining access to the Cloud Library. Every member institution verifies the authenticity of their own members and thereby sends a certificate that contains the details about the user and the privileges enjoyed within the Cloud Library [17].

Token-Based Authentication. A Token is a piece of data that only a specific server could possibly create and contains enough data to identify a particular user. A server issues a token based on the submitted credentials which are used by the Library Cloud member to gain access to the desired service.

4.2 Components of the Library Cloud Concerning its Security Features

Network Access Controller (NAC). NAC is one of the core elements of the security feature for Library Cloud. It is capable of protecting the system from various kinds of potential security threats and ensures that only authorized users can gain access. It is responsible for mediating with the member institutions and deals with the addition and removal of member institutions as well as their respective resources in the Cloud Library.

Cloud Access Controller (CAC). Once the user has been authenticated by the NAC, every activity of the user within the Library Cloud is monitored by the CAC and maintains an audit log regarding every single activity of the user. It is responsible for the resources available and deals with the lending of e-books and other Library resources. It monitors the activities of the user in the interaction platform and is capable of removing the illicit conversations from the discussion topics. It would periodically add journals and books as per the need and requests of the member institutions. It also updates the number of copies of a book (or any other resource) from the resources database when a user borrows or returns it.

4.3 Library Cloud Security Operational Functions

The security operational functions of the Library Cloud as depicted in Figure 2 are discussed in the following steps as well as on how the user gets authenticated:

1. Initially there exists a Firewall between the user and the cloud for the security of both the entities.
2. After passing through the Firewall, the user authentication process begins by selecting the member institution to which the user belongs.

3. The user is then redirected to its member institution's login page for the purpose of authentication, *i.e.*, basically the member system acts as a "*Third Party Authentication System*".
4. Simultaneously, the details of the institution are fetched from the database, which contains the information of the member institutions and the privileges it enjoys in the Library Cloud and fed to the NAC.
5. The user then enters his credentials on the institution login page. Upon verifying the user's details, the member institution authenticates the user by issuing a certificate that contains the information about the user and the privileges enjoyed by the user in the Library Cloud system.
6. The certificate issued by the member institution is forwarded to the NAC.
7. Based on the certificates issued from the member institution and from the database discussed in step 3, the NAC issues a token to access the services in the Library Cloud. The token contains the data about the different privileges the user enjoys based on his/her access level.
8. The token is then forwarded to the CAC which grants the different services, access, and privileges to the user based on the token issued. It also monitors the activities of the user in the Library Cloud and logs this data in a separate database for referencing and various other purposes.

The various services, access, and privileges mentioned above are discussed as follows:

- Different academic institutions are given access to different levels of services depending on the investment made and access levels requested; this aspect is controlled by the NAC and CAC.
- Different members within an institution are granted different levels of access; *e.g.*, a student may have access to only books and magazines, but a faculty member would have unlimited access. This aspect is governed by the NAC and CAC.
- Resources borrowed and resources accessed would be monitored and logged by the CAC.
- Any new addition of resources or change in existing resources is made through the NAC.

5. Analysis of the Advantages and Disadvantages of Library Cloud

This section provides a discussion on the advantages, disadvantages, and probable problems in the implementation of the Library Cloud.

5.1 Advantages of Library Cloud

The advantages of Digital Library were all inherited by Library Cloud as identified below:

- Provides 24x7 services to Library users.
- Reduces manpower required to maintain and run the Library, and thereby save Library resources.
- Provide users with immediate access to the resources of the Library.
- Immediate allocation of resources as required by an institution. For example, e-books can be immediately accessed, whereas, traditional Libraries would take substantial time in allocating books.
- Provides an interactive platform for the students to showcase and share their academic or curricular works.

- Easier accessibility for disabled students and users.
- Ability to store a large amount of data and resources without any need for changes in infrastructure.
- Directly enable students to comfortably search for a variety of relevant resources.
- Every single activity can be recorded and students cannot misuse the resources which is a highly efficient way of Library management [18].

The following includes additional benefits of Library Cloud apart from the advantages of Digital Library mentioned above:

- Loss of Library resources can be prevented in case of a fire accident or any natural/unnatural disaster, as data would be safely saved in the Library Cloud servers [8].
- Global access to the Library resources at any time.
- Any device with Internet connectivity can gain access to the Library Cloud irrespective of the operating system.
- Operational cost is drastically reduced due to the sharing of resources of many Libraries.
- Students and academicians will get access to unlimited resources of information in all forms: Books, Journals, Educational magazines, scholarly articles, and the latest news articles about the world of Technology, Science, and Literature.
- The discussion platform in the Cloud will enable students of the member institutions to collaborate and discuss topics related to academia, suggest books based on experience, help others in choosing the best Books/Journals for a particular topic, and ask relevant queries regarding topics related to their field of specializations.
- The Library Cloud becomes an avenue for discussing topics related to research aiding the academicians, researchers, and students in their works.
- Big University members of Library Cloud can offer courses cutting across all disciplines of science, technology, and literature, and accordingly its library would offer resources relevant to all disciplines, and its students and teachers can access all these resources without any issue.

5.2 Probable Problems and Disadvantages in Library Cloud Implementation

The disadvantages and problems regarding the implementation of Library Cloud are as follows:

- *Copyright Issue*. Sharing of works cannot be done similarly with traditional Libraries. Permissions must be asked for every book copy added to Library Cloud whenever copyright issues exist [19].
- *Skilled Personnel*. Skilled personnel are required for the constant monitoring and aiding in Library Cloud development and maintenance. It is a significant requirement for robust database maintenance since Library resources are shared among different institutions.
- *Internet Connectivity*. Cloud Library operation is basically dependent on the Internet connection.

- *Maintenance*. Inaccessible during Cloud server's maintenance routing (*i.e.*, only for a short period of time).

6. Conclusion

A clear outline of various elements of Cloud computing and how it can be applied to the digital library to form the Library Cloud has been presented. Existing works have been discussed with their general analysis to form the basis of the development and implementation of the proposed Library Cloud model with security features. This paper has outlined the formation of Library Cloud that forms a consortium of Library institutions to provide efficient and effective knowledge sharing. The advantages and disadvantages of Library Cloud have been identified to further enhance the delivery of its services.

In the future, new trends and protocols in authentication techniques will be analyzed and implemented for Library Cloud.

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