

Library Cloud: Concept and Design with Security Features

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ABSTRACT

Cloud computing has the potential to change the world we see today, and this has been duly recognised due to the amazing advantages it offers. One of the main advantages it offers is that cloud computing can reduce the wastage of resources and efficient upgrade effectiveness, increasing the proper application of business computer resources or improving computing device's effectiveness and efficiency of the cloud computing itself can achieve the best applications.

Universities and Colleges are the core of innovation through their advanced research and development. Higher education libraries of different size and type all over the world suffer from common problems such as shrinking budgets, accommodating resources within the budgetary constraints, Countering increased scope of interdisciplinary and multidisciplinary nature of subjects, flexibility associated with the e-data, diminished levels of efficiency, and huge cost involved in managing the entire IT infrastructure in the modern day academic libraries. Cloud computing can overcome these problems and transform the library infrastructure through digitization.

In the proposed paper, the plan is to design a "Library Cloud" which would be the consortium of many digital libraries of different universities/academic institutions and also discuss the security features required to implement this cloud. This "Library Cloud" would help in saving so many resources of the libraries involved and sharing of knowledge amongst the members of the institutions concerned, which otherwise individually would not be feasible and possible.

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1. Introduction

Cloud computing has been accepted as one of the new paradigm in computing that promises to deliver computing as a service. In the future hopefully, cloud services can be marketed as any utility like gas, water, electricity and mobile communication. Clients will access the services over the Internet and pay for only what is accessed similar to any other service.



Figure.1: Different devices being connected to the Cloud

Cloud services are being hosted on a virtualized hardware which can be brought up and eliminated depending on the client requests and needs within a limited period of time [11]. Multiple clients can obtain the services from the virtual hardware. The result of all this sharing of the common hardware resources amongst several users is the raised utilization of the resources downing the overall cost of use. This helps service providers to market the resources at acceptable rates that are far below the cost of purchasing the same resources outrightly. Selling the resources as service is in total contrast to the resources purchased outright or leased from data centres [12]. When the resources leased or purchased, they are being dedicated for a single or few clients irrespective of usage which requires them to pay a fixed fee for the resources rather than the actual services obtained from the resources [17].

Infrastructure as a Service (IaaS), Platform as a Service (PaaS), and Software as a Service (SaaS) are the three main cloud services currently made available by the service providers. Provision of virtual devices including processing power, hard drive space, database storage has been identified as Infrastructure as a Service (IaaS) [9]. Once a virtual device has been purchased, the user can treat it as if it is real hardware and install the operating system and applications of his choice on it. On the other hand, PaaS provides the platform necessary for supporting the complete life cycle of software development. The platform includes the operating system, development and testing tools and Application Programming Interface (API) for development, testing and deployment of web applications [13]. Finally SaaS provides a platform for marketing software applications as services over the Internet instead of as products. Figure.1 depicts the implementation of Cloud Computing and how different people irrespective of their locations are accessing the cloud through various types of devices running on probably various platforms.

The areas in which cloud computing can be employed are vast and it can be still further explored immensely to provide fruitful results in more domains. One such area in which the concept of cloud computing can be employed to give exceptional outcome is the Library. A library by definition is defined as “an organized collection of sources of information and similar resources, made accessible to a defined community for reference or borrowing” [16]. Libraries form the core of centres of the Universities and Colleges, by providing vast resources of knowledge and thereby aiding in the field of research and academia cutting across all disciplines of education. The resources available are in the form of thousands of books, journals, periodicals, newspapers, manuscripts, documents, etc. [1].

Academic establishments face a lot of trouble in providing a Library that fulfils everyone’s need at the institution, due to shortage of resources, budget constraints and other reasons [6]. In the end, due to these shortcomings from the libraries end, it affects the research and academic needs of the affiliated members of the institution [2]. Being in the era of digitization, “Cloud Computing” seemed to provide the most apt solution to this problem, i.e. A “Library Cloud” in which all these libraries could share their resources [7]. This would not only solve their problems but also provide the additional benefits offered by cloud computing [2].

The Libraries are in the period of transition through digitization, by making all the above mentioned resources available in the form of digital data [1]. It is in these digital libraries we can apply the concept of cloud computing to transform our library experience to a completely different level. Everyone can enjoy the various advantageous features offered by cloud computing. One can access the services offered by the library from anywhere, the person doesn’t need to run around to and fro to the library, he can borrow or read any document right from his home. The members of the institution can access study materials and documents relevant to other disciplines. For example, an engineering student/academician can be able to read the books

of other disciplines, like Medicine, Agriculture, etc., which would usually not be available in an engineering institution.

In the proposed paper, the plan is to design a "Library Cloud" which would be the consortium of many digital libraries of different universities/academic institutions and also discuss the security features required to implement this cloud. This "Library Cloud" would help in saving so many resources of the libraries involved and sharing of knowledge amongst the members of the institutions concerned, which otherwise individually would not be feasible and possible.

2. Existing Work

Although it is still a very young concept, there have been a lot of developments in the field of Library Cloud Computing due to the phenomenal rate of developments in the area of Cloud Computing. Many services offer Library Cloud in a variety of ways to the user, but the end result has been to transform the general library experience into a Cloud experience. There are many pros and cons for the various available existing services, which we shall discuss in detail, but when we discuss these features it should be remembered that many of these services are quite young and will improve as the field of Cloud Computing continues to develop and enhance.

2.1. "3M":

It is currently operational in USA and Canada where academic institutions can transform their digital library to the 3M library cloud and enjoy the benefits of cloud computing by accessing it anywhere, anytime and through any device running on any operating system, i.e. Android/ iOS/ Windows [10].

Basically you will be upgrading the digital library service of your institution to a cloud service. Now the members of the institution will be able to access the Library anywhere, anytime, any device irrespective of the operating system it runs, and also the members would enjoy the additional features that are derived from cloud computing.

2.2. Open Library:

Open Library is an online project which intended to create "one web page for every book ever published". One can read/ buy/ borrow for a fee or for free depending upon the publisher [8].

Its book information is usually collected from the Library of Congress, from other libraries, and Amazon.com, as well as from user contributions through a Wiki-like interface. If books are available in a digital form, a button which is labelled "Read" appears next to the catalogue listing. Links from where these books can be purchased or borrowed are also provided.

Open Library claims to have more than 6 million authors and an astonishing 20 million books (not works), and about one million public domain books available as digitized books [8]. Tens of thousands of modern books were made available from 4 and then 150 libraries and publishers for digital lending.

2.3. Google Books:

It is a service that is being offered by Google where one can search online for books also and buy/borrow them from the authors/publishers by paying them a suitable fee or for free if it is made available in the public domain [2].

Results from Google Books show up in both Google Web Search and the dedicated Google Books site (books.google.com). Up to three results from the Google Books index may be displayed, if relevant, above other search results in Google Web Search [19].

A single click on a result from Google Books opens a webpage where the user can view the pages from the book, if the copyright owner has given the permission. Books made available in the public domain are available in "full view" and can also be downloaded for free. For the case in-print books where the permission has been obtained, the number of pages can be viewed is limited to a "preview" set by a variety of access restrictions and security measures. For books where permission for a "preview" has been rejected, only permission for "snippets" (maximum of two or three lines of text) is permitted, but the full text of the book is searchable on a limited basis. For books which neither have "full view" nor "preview", the text here is not searchable, and Google Books furnishes no identification of contents other than the title of the book [19]. It is for this reason; Google Books searches are quite a fallible indicator of the preponderance of the specific terms or usages, since many authoritative works fall into this unsearchable section. In addition to this, even for the available pages, a Google Book search for a specific worded piece of text can fail to show up the relevant sources, particularly if that text appears in a footnote, a figure caption, a boxed insert, or inside some quotation from a consulted source [19].

2.4. Library Cloud:

It's a Harvard Library Cloud Project, which is actually a metadata server that gathers library metadata from multiple institutions and makes it available through the open APIs and also as a Linked Open Data [14].

2.5. Analysis of Surviving Services:

While 3M provides cloud computing service only to the library of the institution you belong, Open library and Google Books provides you a platform where you can access any E-book or document by paying the appropriate fee. None of them provide the service for free, i.e. there is no possibility of sharing of various library resources and serve the greater cause of knowledge sharing amongst the members of the academic institutions and reducing the burden on the libraries. Also there are various restrictions like copyright issues, etc. for accessing the various documents. There is no platform for sharing of documents or thoughts, i.e. no platform for discussion.

3. Model for Implementing the Library Cloud:

The proposed model would include mainly the creation of cloud which would provide the combination of services of *Infrastructure as Service (IaaS)* [5], *Platform as a Service (PaaS)*, and *Software as a Service (SaaS)*. This cloud would be a *Private cloud*, i.e. access would be given to only the member academic institutions and its students and other academicians.

In terms of the storage of all the resources of the various libraries in the cloud, it provides services in the form of IaaS. The Library Cloud would provide services in the form of PaaS due to the various applications that needs to be developed on the cloud, such as:

- a) Database updating upon e-book renting to a member institution
- b) Adding new resources to the cloud or deleting resources from the cloud.
- c) Providing search option for searching various categories of books/journals/etc. and further searching for a specific resource within that category.
- d) Application which licenses and monitors the status of the borrowed resource from the Library to any e-book reader such as *Amazon's Kindle*, and automatically retrieving the borrowed resource upon the expiry of the License.

In terms of providing access to the services of Library Cloud applications over the internet from any internet enabled device, it provides services as a SaaS.

3.1. Working of the Model:

The entire Library Cloud would be basically managed by a Cloud Service Provider (CSP), either completely dedicated for this purpose or otherwise. Now once the Library Cloud is created all the affairs of the cloud would be performed by the CSP including the security features such as the Firewall, protection of the data and the user authentication features. Basically, all the institutions would add their digital library resources to the Library Cloud, once they have done that and have adhered to all the rules and regulations of the cloud they are officially members of the Library Cloud. Then all the members of the institution can access them accordingly. The further details of the working of the cloud are stated below.

- 1) Initially there would be different Levels of Access for the member institutions inside the cloud.
- 2) An academic institution when gaining membership has to invest in the Library Cloud. The investment can be financially or in terms of resources being bought into the cloud by it for sharing with other institutions. Based on this investment the institution shall be granted a Level of Access.
- 3) The Levels of Access means the amount of resources that can be accessed by the member institution. With the lowest being given access to resources concerning only a few disciplines and the highest Level of Access would be the access all types of resources concerning all disciplines.
- 4) Also there would be different Levels of Access to different categories of users within the member institution; like students, teachers, research personnel, etc. could have different Levels of Access or

have the same. These Levels of Access are to be defined by the member institution and stored in the Library Cloud system.

- 5) Once the user has been authenticated and logged into the Library Cloud he can access the cloud for the data that he wants by searching for it. The results of the search would be depending on the Level of Access enjoyed by the user and the member institution.
- 6) The user can access his institution's contribution/ his library in the Library cloud without any restriction.
- 7) Upon finding the book/or other resource the user can refer and use the resource accordingly.
- 8) The user can borrow the book for a particular period of time using the Kindle platform. Or can download the resource if it is not protected by copyright laws.

3.2. Borrowing the book using *Kindle*:

In a normal library the usual way of transaction would be borrowing the books or other resources from the Library. This would not be an issue with the normal library, but in the digital library it is difficult to do so since the issue of copyright arises as the e-books and other digital forms of resources are covered by copyright laws and downloading them would be considered as illegal.

This issue can be resolved by the use of e-book readers, and the most popular and the one considered as pioneers amongst the e-book readers is the *Amazon's Kindle*. Kindle is a popular e-book reader using which we can read e-books, buy and borrow e-books online. It is this borrowing feature that we exploit to our advantage in the Library Cloud [20].

Users will be permitted to download the file only on the Kindle platform. When a user borrows an e-book from the library, the concerned library would attach a license with the e-book; the license contains details such as the period for which the book has been borrowed and the details of the user, book, library. Upon the expiry of the license the book would be unable to read on the Kindle device, thereby solving the copyright issues.

3.3. Interaction Platform:

Library is supposed to be a place where knowledge is gained and knowledge is shared among everyone for the overall enlightenment of the students and academicians. So the digital version of this library should also be no different, hence in the proposed model of Library Cloud there will be an application developed on the cloud using the PaaS feature of the cloud, which would serve as a platform for interaction among the members of library cloud from anywhere about relevant topics. One user from anywhere in the world can discuss with other users regarding queries concerning research, academics, universities, courses, solve each other's queries and exchange ideas. Hence it would in the end serve as a powerful tool in the knowledge sharing and gaining exercise which form the very core founding principles of Libraries.

Different people can recommend books for various topics to help out others who are not having any idea about which is the best book for that specific topic. Users can rate and comment on the books and other resources after using the books. Based on the ratings the user can his search results and choose the best book that would serve his cause. Different users from anywhere in the world who are interested and/or experts in a particular domain can interact with one another relevant to that particular domain and probably help out each other in solving issues regarding their research. There could be many more advantages that could be derived from this interaction platform in the Library Cloud.

4. Security Features for the Cloud:

There would vast amount of valuable resources stored in the Library Cloud, hence protection of the Library cloud is of paramount importance. The Cloud could encounter all the types of attacks ranging from the common types of threats to much more sophisticated type of threats. Hence, firstly the data that has been share by the member institutions are stored in a encrypted form [4]; so that even after all the security features that is provided if an intruder manages to enter the Library Cloud, the resources of the cloud would still be protected. Secondly, the Library cloud here is protected by a state of the art Firewall [1]; which would protect the cloud from all sorts of external attacks. Thirdly, the protection of the cloud is highly ensured if only the right person gains access to the cloud; it is for this reason there has been presented with a detailed authentication procedure so that only the member of the member institution gets access to the cloud. These are shown in Figure 2.

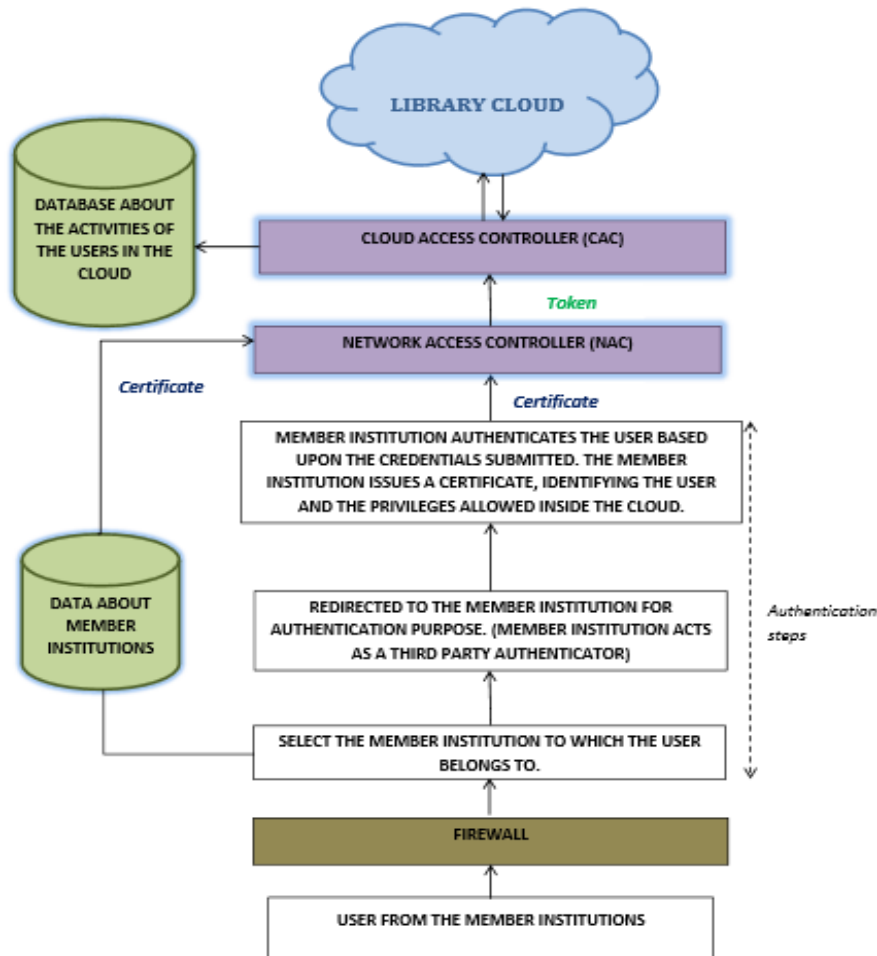


Figure 2: Architecture of the Proposed Model

Figure.2 depicts the architecture of the Library Cloud and the security features associated with the proposed model to protect the cloud from unauthorised users gaining access. Before we explain how the architecture of the cloud works, we shall firstly discuss sections of the cloud depicted in the figure above and few topics that concern the implementation of the cloud security:

4.1. Methodologies Used:

Third Party Authentication: In such a system, the authentication of a user into a particular 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 our model, the member institutions act as an Third Party and they verify the users for the cloud. Every member institution verifies the authenticity of their own members and thereby sends a certificate which contains the details about the user and the privileges he/she enjoys inside the cloud [3].

Token Based Authentication: A Token is a piece of data which only a specific server could possibly have created, and which contains enough data to identify a particular user. A server issues a token based on the credentials submitted to the server, using the token the person gains access to the service desired. Tokens are created using various combinations of various techniques from the field of cryptography as well as with input from the wider field of security research [4].

4.2. Components of the Cloud Concerning Security:

Network Access Controller (NAC): It would form one of the core elements of the cloud. It would protect the cloud from various kinds of security threats and would ensure only the authorised users are gaining access to the cloud. It would be the one that is responsible for mediating with the member institutions and also would be the one that would deal with the addition and removal of member institutions and their respective resources from the cloud.

Cloud Access Controller (CAC): Once the user has been authenticated by the NAC every activity of the user inside the cloud would be monitored by the CAC and it would also maintain a log regarding every single activity of the user. It would be responsible for the resources that is inside the cloud, it would deal with the lending of the books and other resources. It would monitor the activities of the user in the interaction platform and would remove the illegitimate conversations from the discussion topics. It would periodically add the journals and books as per the need and requests of the member institutions.

It would decrement/increment the number of copies of a book (or any other resource) from the resource database when a user borrows/returns it.

4.3. Working Details:

The working of the library cloud and how the user gets authenticated can be explained in the following steps:

1. Initially there exists a Firewall between the user and the cloud for the security of both the entities.
2. Then the process of authenticating the user begins, firstly by selecting the member institution to which the user belongs to.
3. Upon selecting the member the user is redirected to his/her member institution's login page for the purpose of authentication, i.e. basically the member system acts as a "*Third Party Authentication System*".

Simultaneously the details of the institution are fetched from the database, which contains the information of the member institutions and the privileges enjoyed by it in the cloud, and fed to the *Network Access Control (NAC)*.

4. The user then enters his credentials in his/her institution login page. Upon verifying the details the member institution authenticates the user by issuing a certificate which contains the information about the user and the privileges enjoyed by the user inside the cloud.
5. The certificate issued by the member institution is forwarded to the *NAC*.
6. The *NAC* based upon the certificate from the member institution and the certificate from the database discussed in *step 3*, issues a token to access the services in the library cloud. The token basically contains the data about the different access the user enjoys in the cloud and also the different privileges and services this particular user can have inside the library cloud.
7. The token is then forwarded to the *Cloud Access Control (CAC)*, which based on the token issued grants the different services, accesses and privileges to the user. It also monitors the activities of the user inside the cloud and logs this data in a separate database for referencing and various other purposes.

The various services, privileges and accesses mentioned above are discussed below:

- Different academic institutions would be 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*.
- Also different members within an institution would be granted different levels of access; i.e. 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*.
- Also 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. Advantages and Disadvantages:

Now that we have discussed the about the concept of Library Cloud, the existing services and the proposed model for implementing the cloud; we can proceed to look at the advantages, disadvantages and the probable problems in implementing the Library Cloud.

5.1. Advantages of Library Cloud:

The concept of Cloud Computing when applied to a particular area, it always brings a load of advantages with it. In fact, this particular feature of Cloud Computing is what excites the modern era and what has propelled its rapid growth. Hence, it should be no different in the case of Library Cloud Computing.

Basically, Library Cloud Computing provides all the advantages that are offered by the digital library that is mentioned below:

- a) It would offer 24x7 services to the library users.
- b) It would help reduce the manpower required to maintain and run the Library, and thereby save the resources of the Library [16].
- c) It would enable the users to immediate access to the resources of the Library.
- d) Resources can be brought immediately as per the need of the institution. Ex: e-books can be brought immediately when there is an immediate requirement, unlike the traditional libraries where it would substantially take more time.
- e) A more interactive platform for the students to showcase and share their academic or co-curriculum works.
- f) It would aid a lot for disabled students and users in terms of not just accessing the resources, but also the ease with which the resources can be accessed.
- g) Ability to store large amount of data and resources without any need for changes in infrastructure.
- h) It would directly enable the students to search for the resources with more comfort; also it would direct the students to the relevant resources.
- i) A highly efficient way of Library management, as every single activity is recorded and students cannot misuse the resources [15].

The following would be the benefits that would be offered by the Library Cloud apart from the advantages of the Digital Library that were mentioned above:

- i. Protection and prevention of loss of the resources in case of a fire accident or any natural/unnatural disaster, as the data would be safely saved in the servers of the Library Cloud [2].
- ii. Access to the resources from any corner of the world and at any time.
- iii. Ability to gain access to the cloud from any device irrespective of the operating system the device operates on. All you need is an Internet connection [15].
- iv. Due to the sharing of resources of many libraries, the total operating cost of the individual libraries will reduce drastically.
- v. Students and academicians will get access to unlimited resources of information all forms: Books, Journals, Education magazines, and Scholarly articles, latest news articles about in the world of Technology, Science and Literature.
- vi. The discussion platform in the cloud will enable students across the member institutions to discuss topics related to academia, suggest books based on experience and help others in choosing the best Books/Journals for a particular topic, and ask relevant queries regarding some topics related to academics.
- vii. It would act as a forum for discussing topics related to research and ask for queries related to their respective research works; finally aiding the academicians and students in their research work.
- viii. If a member institution is a big University it will offer courses cutting across all disciplines of science, technology and literature and accordingly its library would offer resources relevant to all the disciplines, and its students and teachers can access all these resources without any issue.

But, if a member institution offers only technological courses then it would not have books and their resources relevant to other disciplines. For example: If an engineering student wants to refer some books and articles relevant to medical sciences for some research work where technology can help the medical science, it would not be possible from his academic institution.

Now if the Library Cloud consists of members which are Universities that offer every course, member institutions that offer Technological courses, member institutions that offer Medical

courses, member institutions that offer Agricultural courses, etc. Now we have a Library Cloud that has all the resources from all disciplines and hence a student can just login to the cloud and access whatever information he wants, and thereby aiding the students in their thirst for knowledge and research.

5.2. Probable Problems and Disadvantages concerning the cloud:

There are always two sides to a coin; we have just looked at the advantages. Now we shall look at the disadvantages or problems regarding the implementation.

i. Copyright Issue:

Works cannot be shared over different periods of time like a traditional library. If a copyright issue exists then the permission is to be asked for every copy of book that is to be added to the library cloud [18].

ii. Skilled Personnel:

There would be the need of skilled personnel constantly monitoring and aiding in developing the cloud. Since many libraries are sharing their resources, there is a strong need to maintain the databases of the various resources accurately.

iii. Internet Connectivity:

Basically, without the internet connection the cloud cannot be accessed.

iv. Maintenance:

The cloud would be inaccessible when the cloud's servers undergo its maintenance routine, though only for a short time.

6. Conclusion:

In this paper we have discussed the elements of cloud computing and how it can be applied to the digital library to form the library cloud. In this process we had come across the existing technologies in this field and their general analysis, then we discussed about the model proposed and its features. We also discussed the various advantages and the disadvantages that would be offered by the Library Cloud.


Library is a place where a student goes to quench his thirst for knowledge and it would be an ideal scenario if all the libraries in every academic institution are fully equipped with the resources to ensure the needs of their students. But it is not the case, unless you're in a highly reputed University/institution. But in today's technological world, where technology has solved various issues across every domain and made human's life more comfortable, the issue of shortcomings of the libraries can be definitely solved by sharing of their resources. If the issues of copyright and the other disadvantages can be resolved amicably, then it is of my opinion that the concept of "Library Cloud" and the proposed model can definitely aid the academic institutions and mainly the students enormously, and can become a powerful tool in their quest to fulfil their thirst for research and enlightenment.


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