A cloud-based approach to library management solution for college libraries

Jitendra Nath Shaw and Tanmay De Sarkar
Central Library, University of Calcutta, Kolkata, India

Abstract

Purpose – The study aims to focus on the present automation status of the college libraries with an objective to offer enhanced Web-based library service on an affordable virtualization on cloud computing model.

Design/methodology/approach – With Infrastructure as a Service (Infrastructure as a Service) delivery model, this study demonstrates how libraries of colleges/smaller institutes could be connected to cloud Library Management System infrastructure through internet or dedicated point-to-point WAN connectivity. The Software as a Service (SaaS) delivery model depicts how college libraries could form library consortium at its own private cloud environment with installation of the required LMS application, database, middleware and other prerequisites.

Findings – A cloud-based consortium approach for the college libraries will reduce the cost of purchasing hardware equipment and setting up of infrastructural facilities; relieve libraries of involving additional IT skilled manpower; foster collaborative approach with shared environment and minimise duplication in resource subscription.

Originality/value – To the best of the authors' knowledge, the present study is the first of its kind in the light of shifting of infrastructure, software and hardware requirements of smaller libraries for cooperative sharing in both IaaS and SaaS cloud platform. The study delineates step by step how college libraries could effectively leverage the cooperative cloud architecture for enhanced library services to reach wider user community.

Keywords Library, Consortium, Virtualization, Cloud computing, Big data, Library management system

Paper type Research paper

1. Introduction

The evolutionary advancement of computer and communication technology over the years causes increasing rate of digital data generation with the provisioning of resources for easy accessibility. The requirement to handle volleys of rapidly growing data sets, set forth adoption of such technology which is affordable and easily manageable. Among the gamut of rapidly evolving such technologies, cloud computing perhaps has the answer. On-premise computing resources such as networks, servers, storage, IT applications and services to sharable computing resources have witnessed radical shifts due to application of cloud computing and virtualization technology. The cloud-based service is gaining popularity in every sphere of our life, right from marketing industry to educational field and of course to libraries that support education system. Libraries all over the world are contemplating to having easier access to resources and inflating storage capacity with the provision of reduced capital expense and recurring costs. The social media application in libraries (De Sarkar, 2017; Balaji *et al.*, 2019) aiming at enhanced resource marketing and client collaboration is juxtaposed with virtualization for its optimization in terms of resource utilization.

Among the libraries supporting academic pursuance, college libraries are the intermediate between the school libraries facilitating teaching-learning activities and university libraries providing research facilities along with supporting teaching-learning progression. Majority of the colleges, especially in developing countries like India, application of computer in a library is broadly viewed as an in-house client-server model with specific modules in library software running the system.

Varieties of library automation software are flooded in college libraries and most of the lesser known software are not Z39.2 protocol compliant which signifies a less likelihood of data migration. Proprietary software with provisions of standardized metadata incorporation is largely run in less number of college libraries. The compromization with standardized software, albeit for diverse reason, is hindering the library automation movement. A gradual shift from on-premise networking architecture to a cloud base model will empower college libraries to better manage resources and resolve issues of infrastructure and particularly technical manpower, which a small library, like a college library is usually not supposed to have. Adoption of cloud computing model in college libraries in countries like India is scarce. Therefore, the present study showcased a model for collaborative approach at college libraries to form consortia-based cloud computing architecture. The article focuses on the present status of the college libraries

with an objective to offer enhanced computer-based library service on an affordable virtualization model.

2. Literature review

The idea of cloud computing has its root nourished with evolving technologies – virtualization (hardware), service-oriented architecture (internet), grid computing (grids), utility computing, (business model) and autonomic computing (systems management), intrinsic to huge resource aggregation in a virtualized manner (TYJ and Vadivu, 2019).

In cloud computing, the hardware and software resources are delivered as a service to customers/users. There are three key service architecture being offered through service layers in cloud computing such as Infrastructure as a Service (IaaS) model, Platform as a Service (PaaS) model and Software as a Service (SaaS) model. The IaaS cloud computing service architecture, being the fastest growing in the field (Manvi and Shyam, 2014; Tsai, 2020; Rajasekar and Palanichamy, 2020) offers cloud customers the provision for processing, storage, networking, etc. Virtualization is the key technology for the deployment of IaaS model. The applications are accessible from various client devices through either a thin client interface, such as a web browser (e.g. web-based email), or a program interface, allowing a consumer to manage and control a limited user-specific application configuration settings in SaaS model (Mell and Grance, 2011; Jayaswal *et al.*, 2014).

2.1 Data magnifications and cloud computing

The continuing advances in technology related to big data and analytics has made the adoption of cloud computing increasingly pertinent. With the growing dependence on web by both clients and organizations, and for streamlining the issues concerning space, infrastructure and cost, organizations are fast approaching cloud-based service models to better serve their users in a quicker and easier way (Li, 2012; Laatikainen, 2013; Araujo, 2018; Dutt, 2018; Cardoso, 2018). Giving due importance to the emerging technology, Shawish and Salama (2014) long back defined cloud and provided its architecture and enumerated the basic service models together with a discussion on service cost and security issues. As cloud-based services gained prominence among the user groups because of their flexibilities in service provision and infrastructure, a number of cloud service providers came up. Therefore, Uchibayashi *et al.* (2015) observed that the growing number of cloud service providers providing cloud services with non uniform descriptions makes it very difficult for the customer to choose the best compatible service provider matching their needs. In the course of development and magnification of data generation in terms of velocity and volume, the concept of big data is threatening the conventional tools and techniques we use to preserve and process data. To withstand the ensuing challenge to the computing sectors, Zheng *et al.* (2017) put forwarded workable solution to issues related to big data storage and processing using cloud infrastructure. Using cloud as a major technology enabler for Industry 4.0, firms are establishing business in cloud platforms to handle big data issues (Shou *et al.*, 2019). Mahmoudi (2020), while focussing on image and video processing algorithms for managing large scale database, exploiting big data technologies, proposed a cloud-based toolbox approach to utilise high performance cloud resources, executable in real time. The ability of cloud computing to minimize the workload of an organisation speaks volume of its intrinsic strength that leads business organizations among others to effectively leverage various models of cloud infrastructure.

2.2 Application of cloud computing in different sectors

Applicability of cloud computing is observed in every sphere from education, medical to marketing sectors and almost all large organizations are adopting cloud computing technology which is broadly viewed as an improvement of previously available technologies like cluster, peer-to-peer, and grid computing (Yang, 2014; Mhouti, 2018; Araujo, 2018; Smirnov, 2018; Zandesh *et al.*, 2019; Scalera, 2020). Jianwen and Wakil (2019) discussed various factors affecting adoption of could computing in companies and highlighted the benefits of its use. Srinivasan (2014) observed that medium sized businesses organizations having the computing experts amongst its work force, prefer to choose PaaS model that fits their needs in selecting multiple cloud platforms. He also opined that, while Software as a Service remained the key service quotient at the cloud, larger organizations usually opt for only Infrastructure as a Service to meet their infrastructure requirements. The greater level of acceptance of SaaS model among the above three basic cloud computing models has also been observed by Wang *et al.* (2016). He argued in his paper that, since Enterprise Application Integration (EAI) is the key factor in many organizations, the SaaS can also be applied to EAI, and thus SaaS capabilities can be embedded into traditional web application for greater efficiency. Realizing the prospect of cloud computing technology in education sector, Yang (2014) examined the potentiality of cloud computing in the particular realm, and presented an overview of education cloud, suggesting how an education cloud could be constructed.

2.2.1 Cloud computing in resource sharing

Among the relevant fields, the use of cloud computing in education, particularly in e-learning has been increasingly predominant to minimize the expenditure of educational institutions to maintain infrastructure, hardware and software requirements. Mhouti (2018) focused on the use of cloud computing in e-leaning and highlighted possible benefits of using cloud platform for e-learning deployment. Since the library serves as a vital component of any educational institution to facilitate teaching-learning and research progression, and remains the backbone for e-learning platform and open online courses, sharing of cloud platform by libraries to integrate library services and overcome the problem of handling huge data, growing number of users, shortage of IT skilled manpower and infrastructural facilities remains the emerging trend and a review study of Stukalova (2015) underpinned the importance of adoption of cloud computing in libraries. Ravi and Wang (2020) provides a broad understanding of could computing and digital repository in higher education library. Sun *et al.* (2019) proposed a cloud-based library resource sharing system adopting Hadoop framework for sharing of electronic resources between the university libraries. The proposed system involves cloud library

platform architecture comprising a joint service platform and multiple local library cloud platforms. Kim (2019) proposed a Semantic Library based on ontology and metadata that can renovate information services with sharing, participation and collaboration at a cloud computing environment.

Furthermore, cloud-based library resource sharing models and algorithm have been proposed by researchers to show how libraries can be benefitted with the use of cloud computing. Hu (2019) proposed a cloud-based library information resource sharing using cluster algorithm to evaluate the resource sharing operation mechanism. He introduced key technologies for resource sharing using cloud services followed by model and algorithm of cloud-based library information resource sharing. A few cloud computing models have been designed to show how digital library/library automation can be shared via cloud platform (Zhang, 2015; Stukalova, 2015; Shaw and De Sarkar, 2019). However, no such article has been observed focusing on the consortium approach among a large number of smaller organizations, especially college level libraries, delimited by geographical boundaries, sharing a cloud-based model. Therefore, the present study is particularly significant in the light of shifting of infrastructure, software and hardware requirements of smaller libraries for cooperative sharing in a cloud platform, availing all three basic models of cloud computing.

## 3. On-premise library automation in colleges

Being an intermediary between a school and a university, a college serves as the basis to groom students to prepare for higher learning in universities. Students in a college, besides getting the required infrastructural facility, are supposed to receive educational support from the teaching-learning platform, which in turn is deeply relying on the services provided by the college library. Now a days librarians intend to go beyond traditional library services and integrate themselves with classroom teaching as embedded librarians. Since

e-books, e-journals, ETDS and bibliographic databases constitute major learning materials, besides class notes, syllabi, project reports, question papers, etc., it is incumbent for colleges to create institutional online repository for all learning materials for easier and smoother access to resources. Compared to a university, a college hardly finds the opportunity to properly serve its clientele with facilitated library service due to constraints in terms of availability of funds, space, staff, etc. Consequently, while implementing automated library services, many college libraries are facing multiplicity of problems not only pertaining to upgradation of the system in tune with the rapid development in computer and communication technology but also to maintenance of products and services the way they require.

At present, every college/small institutional libraries are providing library services through their on-premise-based library management system to their clientele principally constituting students and faculty members. Figure 1 and Figure 2 depict the traditional form of on-premise-based library management system.

A college library basically requires almost the same infrastructure as that of a university library, albeit in a lesser magnitude, depending on the number of students enrolled, to set up library management system to offer library services to students, teachers and to scholars in some postgraduate colleges. However, the financial constraints to purchase servers, computers as client machine and software for a robust networking platform, are more conspicuous in a college compared to a university. Additionally, installation and implementation of library automation systems and services require the involvement of experts in the relevant field which a college library is usually deprived of. Since a college library normally does not have any permanent post for a skilled IT professional to manage hardware and software related issues, the librarian of a college library often outsources the whole IT works, which magnifies the cost to a larger extent.

Figure 1 On premise LMS architecture for college libraries
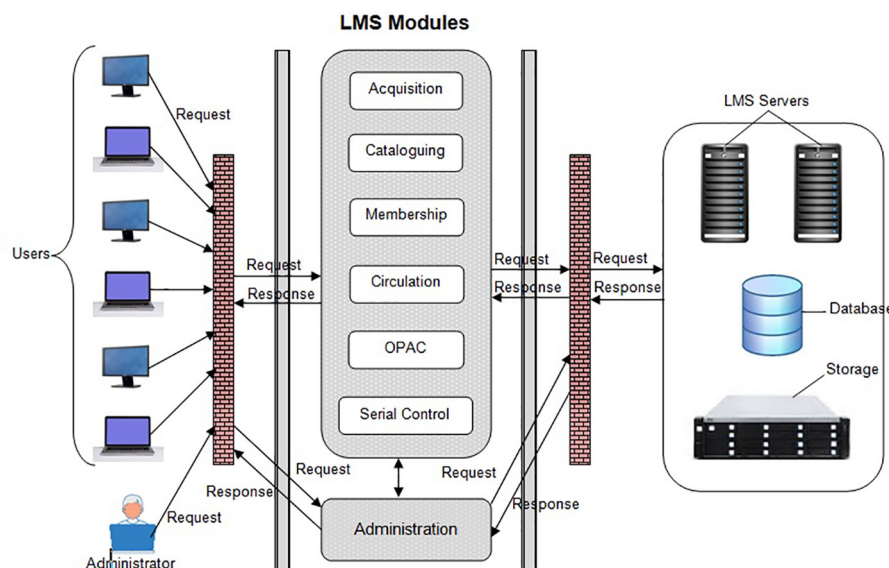
Figure 2 On premise LMS for college libraries
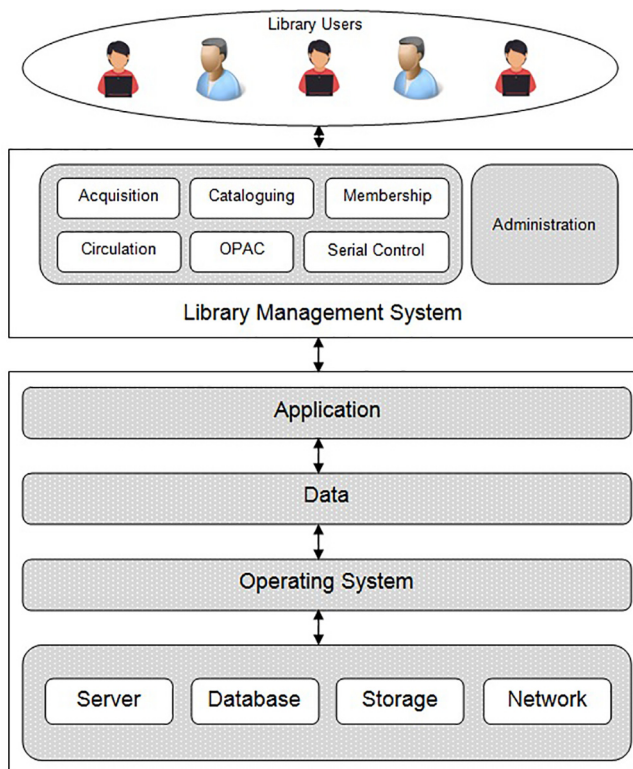
4. Cloud-based virtualization model for college libraries

We propose a cloud architecture for college libraries to address the aforesaid issues. In the proposed cloud architecture, college libraries are shown to be brought under a single window library automation system, using cloud-based computing technology. Out of three cloud delivery models, such as Infrastructure as a Service (IaaS), Platform as a Service (PaaS) and Software as a Service (SaaS), the two most popular cloud delivery models 'Infrastructure as a Service' (IaaS) and 'Software as a Service' (SaaS) are considered here. In a cloud computing environment, a librarian of a college/institutes is relieved of making large investment to purchase hardware and servers and he/she does not require spending a lot of time on managing hardware related issues. However, a librarian can get exactly the right type and size of computing resources such as server type, memory, storage, etc., essential to run Library Management System (LMS) on a cloud infrastructure. The cloud computing infrastructure allows librarians to run their existing on-premises LMS applications on cloud-based LMS infrastructure with full support and high performance provided through cloud-based shared multi-library consortium approach, which ensures that participating libraries are relieved of the problems they face in running standalone traditional library system.

In this paper, we also propose to interlink libraries of colleges or small institutes through a common gateway of cloud infrastructure, using internet network topology, which helps the libraries to share their bibliographic databases of library holdings, basically of books and journals, both physical and

electronic forms, full-text online institutional repository and provide library services to their clientele using the shared platform.

4.1 Infrastructure as a Service-based Library Management System delivery model

In Infrastructure as a Service (IaaS) delivery model, libraries of colleges/smaller institutes are connected to cloud LMS infrastructure through internet or via dedicated point to point WAN connectivity. A library consortium forms its own private cloud infrastructure and connects all the college/smaller institutes libraries privately with that cloud infrastructure using virtualisation technology i.e. creating virtual machine (VM) for each library. Apart from this, a library consortium also forms library cloud infrastructure for libraries on any public/private cloud infrastructure platform, provided by cloud service providers such as Microsoft cloud, Amazon cloud, Google cloud, IBM cloud, etc. A virtual machine (VM), so provided by a cloud consortium, to a college/small institutional library, acts an individual server for LMS application used by that college/ small institutional library. Virtualisation plays a key role to provide cloud-based infrastructure-service to different users i.e. libraries. A library consortium is destined to providing infrastructure-resources to libraries and is actively engaged in monitoring and maintenance of that infrastructure-resources (i.e. networks, servers, storage). The provisioning of infrastructure-resources, as provided on cloud to run LMS application, makes it simplified for a library administrator to install the operating system (OS), middleware, database and LMS application software and its prerequisites. Once the infrastructure-resources are available on cloud, a library administrator may initiate data migration from on-premise LMS system server to cloud-based LMS system and provides services to their students, faculty members and scholars. While migrating data, from on-premise LMS platform to cloud-based LMS, it is essential to check the interoperability of metadata architecture exists in two LMS platforms. In order to access LMS application modules, a librarian needs only computers with dedicated connection to cloud LMS server or connection through internet. The LMS application is accessible via web browsers. The proposed model shall relieve the librarian of the burden to maintain on-premise LMS server. Figure 3 illustrates IaaS cloud LMS model for colleges/small institutional libraries.

Shaw and De Sarkar (2019) in their paper, demonstrated a cost-benefit analysis based on cloud LMS solution in comparison with on-premise library automation system for university libraries ie, libraries having huge collection of books, journals, periodicals, etc., under the single window platform. In this paper we aimed at the smaller sized libraries like college libraries or libraries of institutes having smaller collections of resources to bring them under the consortia approach for better and easier visibility and accessibility of resources and services, using cloud computing architecture. Since college libraries have lesser collection of resources compared to university libraries, whilst their requirement in terms of service perspective is similar to bigger libraries to run on-premise traditional LMS, a consortium approach for the college libraries is highly required to reduce the cost of purchasing hardware equipment and setting up of infrastructural facilities.

Figure 3 IaaS cloud LMS model for college libraries
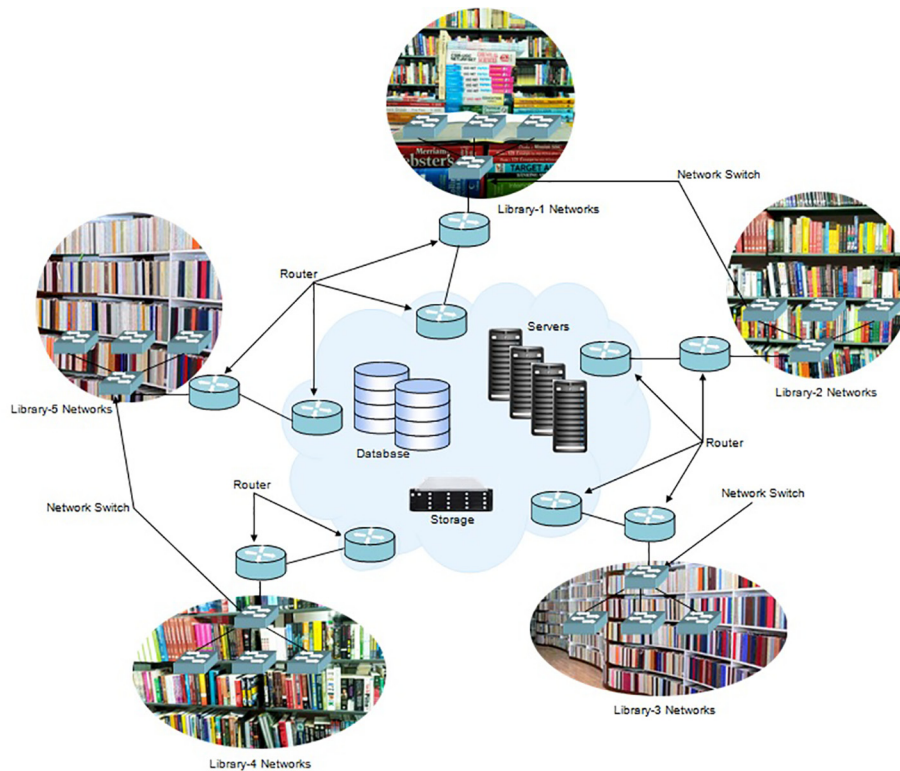
In our present study, we have demonstrated how to design a virtual environment for IaaS cloud-based LMS model on a standalone server, using virtualization technology to create virtual machines (VMs) for libraries of different colleges/smaller institutes, sharing physical hardware resources, such as CPU, memory, storage, etc., and installing Windows/Linux operating system on VMs.

4.1.1 Simulation

To ensure the workability of the aforesaid IaaS delivery model for libraries of colleges/smaller institutes, we simulated a cloud model in standalone server with 2 Nos. of Intel Xeon @ 2.5 GHz processor, 64 GB RAM, 10 TB storage. We have used VMware ESXi hypervisor to create instances (virtual machines) for different college libraries on standalone server to share hardware resources among the participating libraries. The hypervisor directly runs on physical hardware of the simulation server. We created instances (virtual machines) on simulation server with the installation of required operating system (Windows or Linux) on virtual machines for each college library based on their hardware requirements. The combination of hardware resources allocated to different kinds of college/institute libraries is given in Table 1.

After allocating virtual machines for the libraries, the LMS software and database with prerequisites were installed on virtual machines. Different LMS software and prerequisites with database have been installed and configured on each VM using web console. The 3 Nos. of college libraries were privately connected with IaaS cloud LMS via their respective LAN and WAN links. The simulation architecture, ie IaaS-based cloud virtualization model for college libraries is depicted below in Figure 4. Library administrators can configure and manage their library LMS installed on respective virtual LMS server at cloud IaaS infrastructure directly though web console of computers connected to library LAN.

The "Magic Quadrant for Cloud Infrastructure as a Service, Worldwide" as devised by Gartner, July 2019(https://www.gartner.com/doc/reprints?id=1-1CMAPXNO&ct=190709&st=sb) categorised cloud providers under different facets, like leaders, niche player, challengers and visionaries. The aforesaid quadrant gives provisioning of companies offering public and private cloud IaaS solutions. Among the leaders of IaaS providers, the Amazon AWS (https://aws.amazon.com/) was chosen for creation of free IaaS instance. On AWS web portal, virtual machines, called instances were created and run via

Table 1 Hardware allocation for different libraries

Types of Library	Instances	Hardware collection			Operating system to run LMS software
		CPU	Memory (GB)	Storage (TB)	
Small Library	VM1	1	2	1	Windows/Linx
Medium Library	VM2	2	4	2	Windows/Linx
Large Library	VM3	2	6	4	Windows/Linx

Figure 4 IaaS cloud virtualization architecture for college libraries
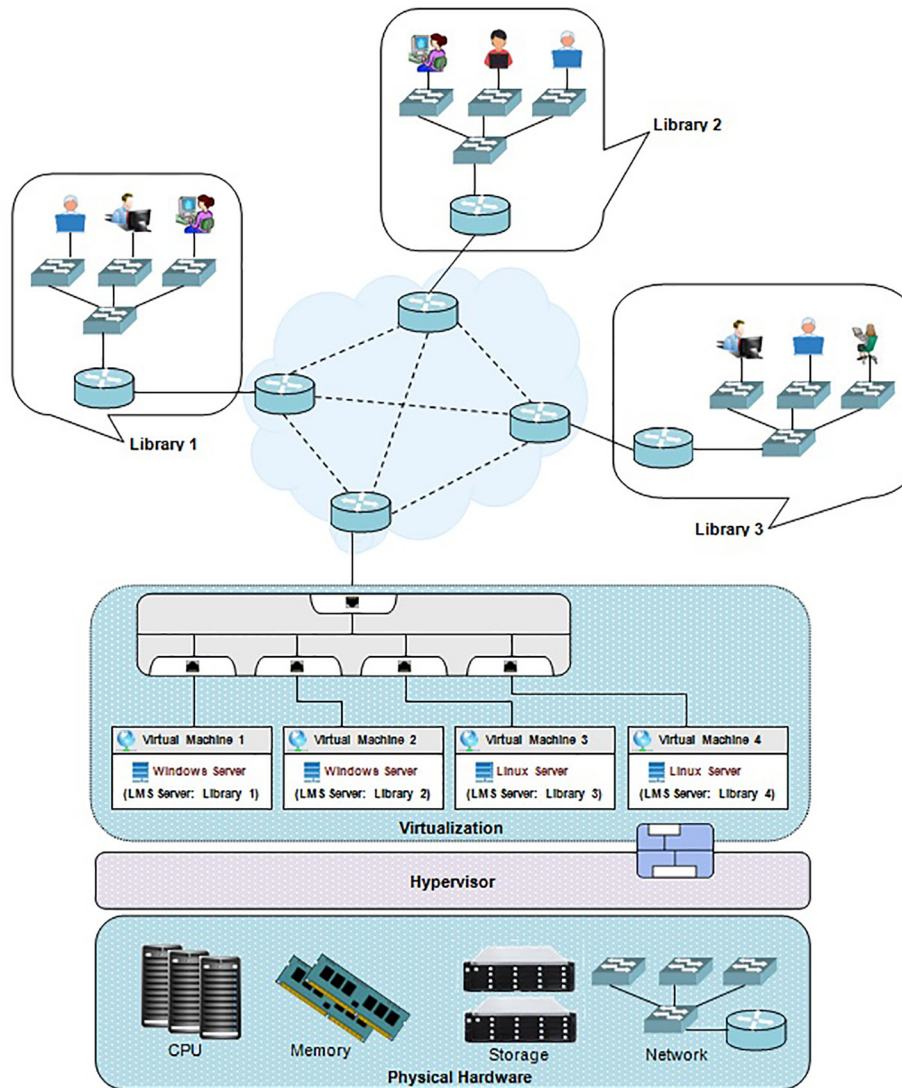
Amazon EC2 console. The EC2 console provides option to choose an instance type with CPU, memory, storage and network of various capacity. AMI (Amazon Machine Image) on AWS EC2 console has the provision to select and configure OS (Windows/Linux/RedHat Linux/Ubuntu Linux, etc.) application server and different applications, depicted in Figure 5.
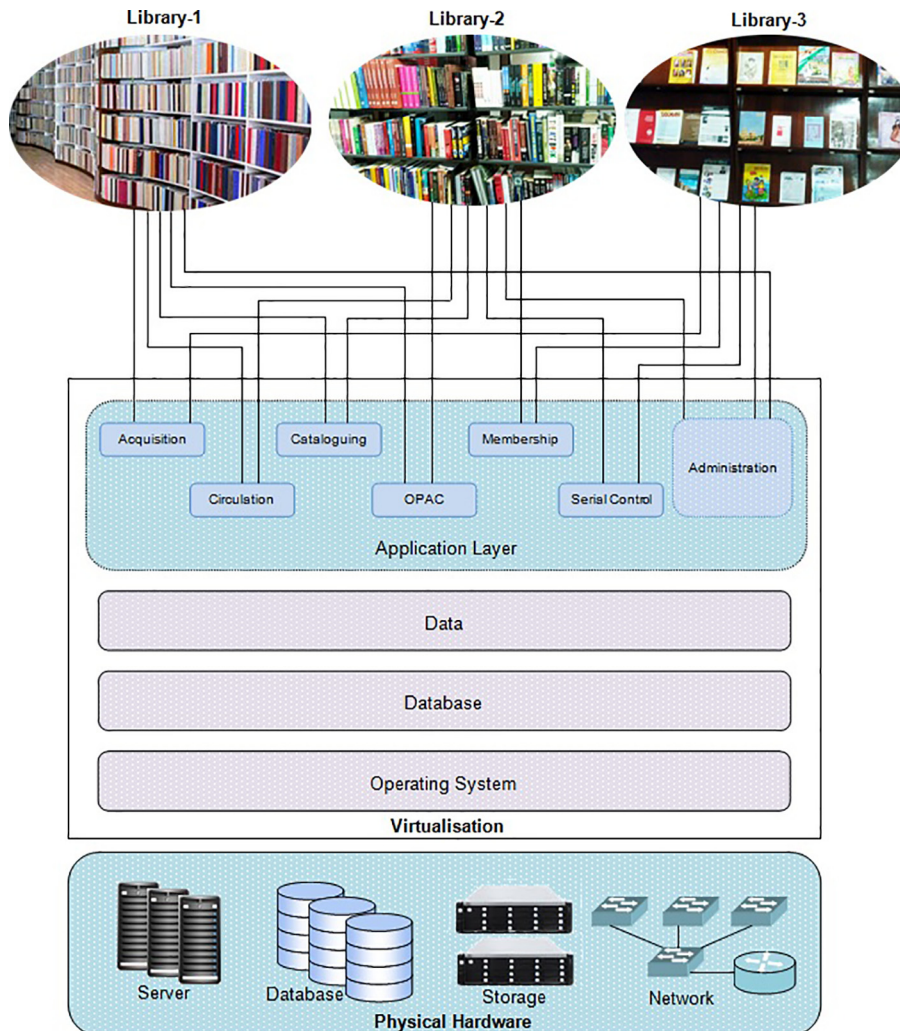
4.2 Software as a Service-based Library Management System delivery model

In our second approach with Software as a Service (SaaS) delivery model, we demonstrated how a library consortium could form its own private cloud infrastructure with installation of the required LMS application, database middleware and other prerequisites. Libraries of colleges/smaller institutes may connect privately through web browser to cloud LMS application. In SaaS cloud LMS model, a library consortium shares its total cloud infrastructure with LMS application and database among the libraries. The library consortium here is

responsible for both, providing infrastructure resources with software application to libraries as well as the installation and configuration of LMS software and database, in addition to monitoring and maintenance of infrastructure resources (i.e. networks, servers, and storage) on behalf of the libraries. The entire cloud service provision is customised with security authentication i.e. User ID & password for the libraries. In order to access SaaS LMS application modules, a librarian needs only some computers with dedicated or internet-based connection to cloud LMS server. The LMS application is accessible via web browsers. Figure 6 shows SaaS cloud LMS delivery model for libraries of colleges/small institutes and Figure 7 illustrates on-premise LMS with two different cloud-based LMS models i.e. IaaS-based LMS and SaaS-based LMS for library automation system:

Additionally, libraries of colleges/small institutes can have the provision to access the cloud-based LMS software services as 'software-as-a service' (SaaS) application to provide services to patrons like faculty members, undergraduate and

Figure 5 Amazon EC2 console for instances (http://aws.amazon.com\getting-started/tutorials/launch-window-vm/)
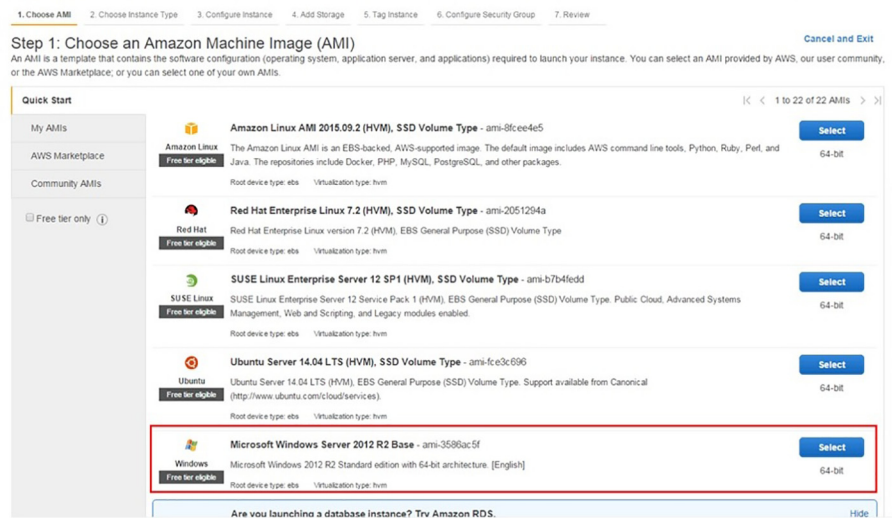
Figure 6 IaaS cloud LMS delivery model for college libraries

Jitendra Nath Shaw and Tanmay De Sarkar

Figure 7 Illustrate on premise LMS with two different cloud based LMS models
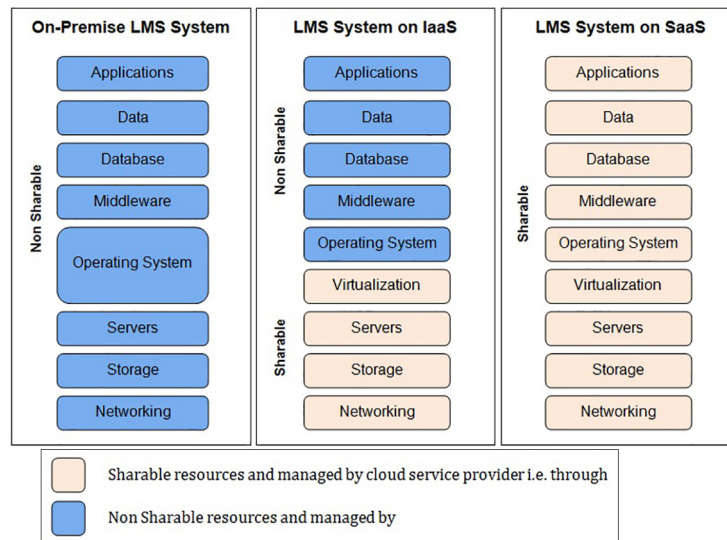
postgraduate students, and research scholars to help them harness library resources and services using online catalogues of books, journals, theses; via portal to access full-text e-resources together with other related resources and facilities. The proposed model shall enable libraries of colleges/small institutes to offer library services to the stakeholders of their parent institutes, irrespective of geographical barriers with minimum funds and technical involvement.

4.3 Facets of library services on cloud platform

Our proposed model on cloud computing technology is pervasive to major technical works being performed in a library, right from procurement of books and periodicals to satisfy users requirements and finally issuing library clearance certificate. The proposed cloud model for college/small institutional library migrates the whole automation services such as acquisition service, circulation service, catalogue service, OPAC, serial control and administration on the cloud platform, which provides the LMS administrator and library staff a freedom to provide and access library automation services from on-premise or from off-campus irrespective of geographical location.

4.3.1 Processing of library documents

Processing of books, periodicals and other library documents shall be streamlined with the provisioning of recording of documents from anywhere within the library premises using a computer connected to cloud LMS server. Furthermore, the provision of in-house processing may be extended to extra library premises subject to the library has a remote-access VPN connection facility. Moreover, recommendations for procurement of books and periodicals may be obtained from the academic community of the college using cloud LMS. Once processing of documents are completed, followed by procurement, the scanned images of the cover pages of the newly arrived books can be uploaded using the cloud LMS module for wider viewership. Similarly, the selective dissemination of information service may be initiated with the

arrival and processing of new issues of journals, provided the scholars database with updated requirements is maintained on the cloud platform with the objective of providing the particular service in view.

4.3.2 Membership registration

Enrolments of new entrants in the college/small institutional library may be made smoother using proposed cloud model. New entrants may upload the documents pertaining to membership registration on the cloud module. Apart from using the provision of depositing library fees through select portal as usual, the new entrants may opt for cloud platform for depositing library fees directly. The fees deposited and other documents uploaded by the new entrants may be verified by the library staff on the same cloud platform. Consequently, the new entrants shall receive the confirmation about their membership registration. Only the physical form of membership card may be handed over to them on arrival.

4.3.3 Lending of library documents

Though the physical check-in and check-out of library books require the user to be personally present in the library, other activities associated to library lending service like placing demand for books, renewal of lent items, payment of overdue charges, etc., may be extended to public domain provided the cloud LMS server is connected to both private and public cloud. The statuses of documents under library holdings may made visible to the library members via Online Public Access Catalogue module of cloud LMS, irrespective of geographical boundaries.

4.3.4 Notifying users about new services and facilities introduced

The proposed cloud model for college/small institutional libraries can be variously exploited to provide mass current awareness service, notify users to new additions, modifications in service components, in terms of digitisation of resources, collection development, exhibitions mounted, etc., with a virtual library tour.

4.3.5 Issuing online library clearance certificate

With the provisioning of obtaining students data relating to library enrolment stored in the cloud, and on being confirmed about the no pending user status pertaining to library related dues, a library may issue library clearance certificate either on-premise or off campus, using our cloud-based approach.

Therefore, in cloud-based LMS system (i.e. IaaS or SaaS cloud LMS model), there is a complete shift of librarian's responsibility of buying, controlling and maintaining of the infrastructure or/and software from library premises to cloud providers i.e. cloud-based library consortium. Cloud architecture is shared by various aggregators and publishers providing online access to books, journals and databases through their web portal. Individual libraries and library consortia are getting access to perpetual/subscribed e-resources via publishers or aggregators cloud platform. To maintain the academic integrity, libraries are using plagiarism detection or similarity checking solutions from respective portals of the companies, hosted in cloud infrastructure for storing, managing and retrieving data.

5. Conclusion

In this paper we intended to showcase web-based or point-to-point client-server architecture of cloud computing model for library management system running on cloud environment for college/small institutional library. The cloud environment in its consortium approach provides multi-tenant infrastructures and services for libraries. We have discussed our cloud computing model for small institutional libraries on IaaS and SaaS platform. Our proposed cloud consortium comprising smaller libraries facilitates sharing of hardware resources, such as CPU, memory, storage, and others, among the participating libraries through virtual machines (VM) running on virtualization software i.e. hypervisor. The Integrated library management software, databases, and other tools and applications may be installed at respective VMs under the cloud. Individual libraries can obtain access to their LMS system through their respective VMs installed in the cloud through a user-defined authentication policy. Since SaaS model for cloud computing is the most chosen platform for smaller organisations world-wide, we suggest college libraries to initially adopt SaaS platform in a cooperative setting, for a broader collaborative approach. However, the sophistication of SaaS platform, for its collaborative setting, requires an efficient library software which has its inherent compatibility as well as the vigour to function on SaaS platform.

While implementing cloud computing in college libraries, following issues are to be kept in mind. The execution of our proposed model on cloud architecture (IaaS architecture) rests upon the provision of consortia or fusion approach among the participating libraries in public cloud or private cloud environment. Internet connectivity with appropriate bandwidth, together with basic infrastructure, including the appropriate LMS software are the prime requirements to access the cloud architecture smoothly from respective libraries and run the library network in a collaborative setting. Framing of appropriate policy guideline, entailing the colleges libraries in a fusion approach over the cloud platform, is very vital for proper implementation of the project.

Our proposed model is limited within college libraries/academic libraries of small institutes. Further research may be carried out to devise cloud model for public libraries over a wide span of network. Unlike college libraries, public libraries have undefined categories of users, involving all sections of the society. The diversity of user group requires incorporation of a wide range of service provisions and implementation of a robust architecture to accommodate n number of nodes. Furthermore, as security issues are inherent to any cloud architecture, proper attention needs to be paid to the data security as well. As such, our proposed model did not highlight any additional data security issues. To avert any security threat as regard to data safety, a secured mechanism, to authenticate users via login access to cloud LMS is needed. Future research may focus on improved cloud library security implementation; either a hardware-based security or software-based security, between users involving administrator, library staff, students, scholars & teachers, and cloud architecture. Since blockchain technology has been evolving as the single most preferred choice in terms of data security, among different sectors, future research may highlight on the application of blockchain technology, integrated with cloud architecture, for improved cloud security measure among the fusion libraries in colleges.

Our proposed cloud architecture may share databases of various resource providers, offering online access to e-resources. Our model will work in its fullest capacity provided a cloud-based library software is installed. The proposed model demonstrated the shifting of infrastructure, software and hardware requirements of smaller libraries for cooperative sharing in both IaaS and SaaS cloud platform. The model will guide library professionals to effectively leverage the cooperative cloud architecture for enhanced library services to reach wider user community. The proposed model will also encourage researchers to work on various cloud security issues as discussed above. Our model on IaaS platform will assist faculty members of 'library and information science' to improve the understanding of the students on cloud library architecture while taking classes on cloud implementation in library.

References

Amazon Web Services (2020), available at: https://aws.amazon.com/choosing-a-cloud-platform (accessed 27 January 2020).

Araujo, J., Maciel, P., Andrade, E., Callou, G., Alves, V. and Cunha, P. (2018), "Decision making in cloud environments: an approach based on multiple-criteria decision analysis and stochastic models", *Journal of Cloud Computing*, Vol. 7 No. 1, p. 7.

Balaji, B.P., M.S., V., B.G., S., J.S. and M.R. (2019), "Web 2.0 use in academic libraries of top ranked Asian universities", *The Electronic Library*, Vol. 37 No. 3, pp. 528-549, doi: 10.1108/EL-12-2018-0248.

Cardoso, A., Moreira, F. and Escudero, D.F. (2018), "Information technology infrastructure library and the migration to cloud computing", *Universal Access in the Information Society*, Vol. 17 No. 3, pp. 503-515.

De Sarkar, T. (2017), "Adopting a photo-sharing site as a library tool: a web-based survey", *Information and Learning Science*, Vol. 118 Nos 3/4, pp. 185-209.

Dutt, A., Jain, H. and Kumar, S. (2018), "Providing software as a service: a design decision (s) model", *Information Systems and e-Business Management*, Vol. 16 No. 2, pp. 327-356.

El Mhouti, A., Erradi, M. and Nasseh, A. (2018), "Using cloud computing services in e-learning process: benefits and challenges", *Education and Information Technologies*, Vol. 23 No. 2, pp. 893-909.

Hu, Y. (2019), "Library information resource sharing cloud service based on cloud computing mode", *Journal of Intelligent & Fuzzy Systems*, Vol. 37 No. 5, pp. 5867-5875.

Jayaswal, K., Kallakurchi, J., Houde, D.J. and Shah, D. (2014), *Cloud Computing: Black Book*, Dreamtech Press.

Jianwen, C. and Wakil, K. (2019), "A model for evaluating the vital factors affecting cloud computing adoption", *Kybernetes*, Vol. 49 No. 10, pp. 2475-2492, doi: 10.1108/K-06-2019-0434.

Kim, B. and Kim, J. (2019), "A reference model for semantic enabled services library system", *International Journal of Advanced Science and Technology*, Vol. 28 No. 5, pp. 100-110.

Laatikainen, G., Ojala, A. and Mazhelis, O. (2013), "Cloud services pricing models", *International Conference of Software Business*, *Springer, Berlin, Heidelberg*, pp. 117-129.

Li, D., Gong, Y., Shen, N. and Qin, T. (2012), "Design and security strategy analysis for SaaS and private cloud-based OA platform", *Technology for Education and Learning*, Springer, Berlin, Heidelberg, pp. 251-258.

Mahmoudi, S.A., Belarbi, M.A., Mahmoudi, S., Belalem, G. and Manneback, P. (2020), "Multimedia processing using deep learning technologies, high-performance computing cloud resources, and big data volumes", *Concurrency Computation*, Vol. 32 No. 17, doi: 10.1002/cpe.5699.

Manvi, S.S. and Shyam, G.K. (2014), "Resource management for infrastructure as a service (IaaS) in cloud computing: a survey", *Journal of Network and Computer Applications*, Vol. 41, pp. 424-440.

Mell, P. and Grance, T. (2011), "The NIST definition of cloud computing", NIST, available at: http://csrc.nist.gov/publications/nistpubs/800-145/SP800-145.pdf (accessed 17 February 2020).

Rajasekar, P. and Palanichamy, Y. (2020), "Scheduling multiple scientific workflows using containers on IaaS cloud", *Journal of Ambient Intelligence and Humanized Computing*, pp. 1-16, doi: 10.1007/s12652-020-02483-0.

Rivai, M.A. and Wang, G. (2020), "Cloud computing platform services in the university libraries for digital repository", *International Journal of Advanced Trends in Computer Science and Engineering*, Vol. 9 No. 1, pp. 285-294, doi: 10.30534/ijatcse/2020/43912020.

Scalera, M., Gentile, E., Plantamura, P. and Dimauro, G. (2020), "A systematic mapping study in cloud for educational innovation", *Applied Sciences (Sciences)*, Vol. 10 No. 13, doi: 10.3390/app10134531.

Shaw, J.N. and De Sarkar, T. (2019), "Model architecture for cloud computing-based library management", *New Review of Information Networking*, Vol. 24 No. 1, pp. 17-30.

Shawish, A. and Salama, M. (2014), "Cloud computing: paradigms and technologies", *Inter-Cooperative Collective Intelligence: Techniques and Applications*, Springer, Berlin, Heidelberg, pp. 39-67.

Shou, Y., Zhao, X. and Chen, L. (2019), "Operations strategy of cloud-based firms: achieving firm growth in the bigdata era", *International Journal of Operations & Production Management*, Vol. 40 No. 6, doi: 10.1108/IJOPM-01-2019-0089.

Smirnov, Y.V. (2018), "The use of classification in information-retrieval languages in cloud library information systems", *Scientific and Technical Information Processing*, Vol. 45 No. 1, pp. 35-39.

Srinivasan, S. (2014), *Cloud Computing Basics*, Springer.

Stukalova, A.A. and Guskov, A.E. (2016), "Publications on the use of cloud technologies at libraries", *Scientific and Technical Information Processing*, Vol. 43 No. 1, pp. 47-57.

Sun, N., Li, Y., Ma, L., Chen, W. and Cynthia, D. (2019), "Research on cloud computing in the resource sharing system of university library services", *Evolutionary Intelligence*, Vol. 12 No. 3, pp. 377-384.

Tsai, W.L. (2020), "Constructing assessment indicators for enterprises employing cloud IaaS", *Asia Pacific Management Review*, doi: 10.1016/j.apmrv.2020.06.001.

Tyj, N.M. and Vadivu, G. (2019), "Adaptive deduplication of virtual machine images using AKKA stream to accelerate live migration process in cloud environment", *Journal of Cloud Computing*, Vol. 8 No. 1, available at: https://doi.org/10.1186/s13677-019-0125-z (accessed 4 January 2020).

Uchibayashi, T., Apduhan, B. and Shiratori, N. (2015), "Towards a cloud ontology clustering mechanism to enhance IaaS service discovery and selection", *International Conference on Computational Science and its Applications*, Springer, Cham, pp. 545-556.

Wang, BLie., Liu, H. and Song, J. (2016), "SaaS-based enterprise application integration approach and case study", *The Journal of Supercomputing*, Vol. 72 No. 7, pp. 2833-2847.

Yang, L. (2014), "Education cloud: new development of informationization education in China", *Frontier and Future Development of Information Technology in Medicine and Education*, Springer, Dordrecht, pp. 1259-1266.

Yang, X., Wang, D., Jiang, L., Ma, J. and Xie, H. (2014), "Study on cloud service mode of digital libraries based on sharing alliance", *International Conference on Computer and Computing Technologies in Agriculture*, *Springer, Cham*, pp. 404-410.

Zandesh, Z., Ghazisaeedi, M., Devarakonda, M.V. and Haghighi, M.S. (2019), "Legal framework for health cloud: a systematic review", *International Journal of Medical Informatics*, Vol. 132, doi: 10.1016/j.ijmedinf.2019.103953.

Zhang, F., Gao, Z. and Ye, Q. (2015), "Construction of cloud platform for personalized information services in digital library based on cloud computing data processing technology", *Automatic Control and Computer Sciences*, Vol. 49 No. 6, pp. 373-379.

Zheng, X., Fu, M. and Chugh, M. (2017), "Big data storage and management in SaaS applications", *Journal of Communications and Information Networks*, Vol. 2 No. 3, pp. 18-29.

About the authors

Jitendra Nath Shaw is Information Scientist for the University of Calcutta and a Visiting Lecturer for the Department of Library and Information Science, University of Calcutta. He has authored many research articles in international peer-reviewed journals. His research areas include networking, cloud computing, library automation and Web applications. He holds a BSc, PGDCA, MCA and M.Tech. degree. Jitendra Nath Shaw is the corresponding author and can be contacted at: jnshaw@caluniv.ac.in

Tanmay De Sarkar is Assistant University Librarian for the University of Calcutta and a visiting lecturer for the Department of Library and Information Science, University of Calcutta. He has authored many research articles in international peer-reviewed journals. His research areas include library networking, e-resource management and web-based applications. He holds an MSc degree, BEd degree and PhD degree from the University of Calcutta, and an MLIS degree from the Jadavpur University.