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Fall 9-5-2021

A Model Approach to Cloud Implementation on Public Libraries with a focus on West Bengal, India

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De Sarkar, Tanmay , Corresponding author and Shaw, Jitendra Nath , Main author, "A Model Approach to Cloud Implementation on Public Libraries with a focus on West Bengal, India" (2021). *Library Philosophy and Practice (e-journal)*. 6270.

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A Model Approach to Cloud Implementation on Public Libraries with a focus on West Bengal, India

Abstract:

The purpose of this paper is to explore the possibility of introducing cloud architecture for public library system in areas where library automation is operational on a standalone server. It also proposes a cloud based model library management system to function on an affordable, robust architecture. The paper made an attempt to highlight the present status of library automation and networking among public libraries in West Bengal. It presents functional requirements for a SaaS based (Software as a Service) model. The simulation approach for the model architecture supports the possibility to connect all public libraries across different hierarchical tiers under the public library system of West Bengal. The proposed model will upscale workflow, reduce cost and duplication of work in terms of procurement, cataloguing, classification and creating an union catalogue/ OPAC with the provision of resource sharing. The current study is the first of its kind, proposing a SaaS cloud based model architecture for a huge public library network. It suggests ways to improve public library services and coordination across the network to visually present the holdings of the entire network to the user community via a cost effective infrastructure.

Keywords: Public Library, Cloud computing, SaaS, Big data, Networking, West Bengal

1. Introduction

The development of public libraries and emergence of a public library system in West Bengal, in eastern India, have received greater attention with the introduction of West Bengal Public Library Act, 1979, long after the first public library act enacted in India, in 1948 for Madras, the southern state in India, as Madras Public Library Act, just after independence in 1947 (Kumar and Shah, 2000). The West Bengal public library network presently spreads across all the 23 districts encompassing the remote rural areas to smaller towns, subdivisions and districts. Public libraries in West Bengal are broadly categorised into government sponsored public libraries and non-government non-sponsored libraries. Since government sponsored public libraries come under direct administrative control of the government of West Bengal and have a definite organizational structure, in our project, we restricted our study on the government sponsored public libraries only. The government sponsored public libraries in West Bengal, hitherto shall be referred to as public libraries in West Bengal, and have the following ramifications: Primary unit library (PUL) at the sub-urban level (municipal areas); rural library at village level (panchayat areas); town library at towns; sub divisional library at subdivisions and district library in districts. The hierarchical diagram of Public Library System in West Bengal is shown in Figure 1 and the details of these types of libraries are available in Table 1 (<http://www.wbpublibnet.gov.in/>)

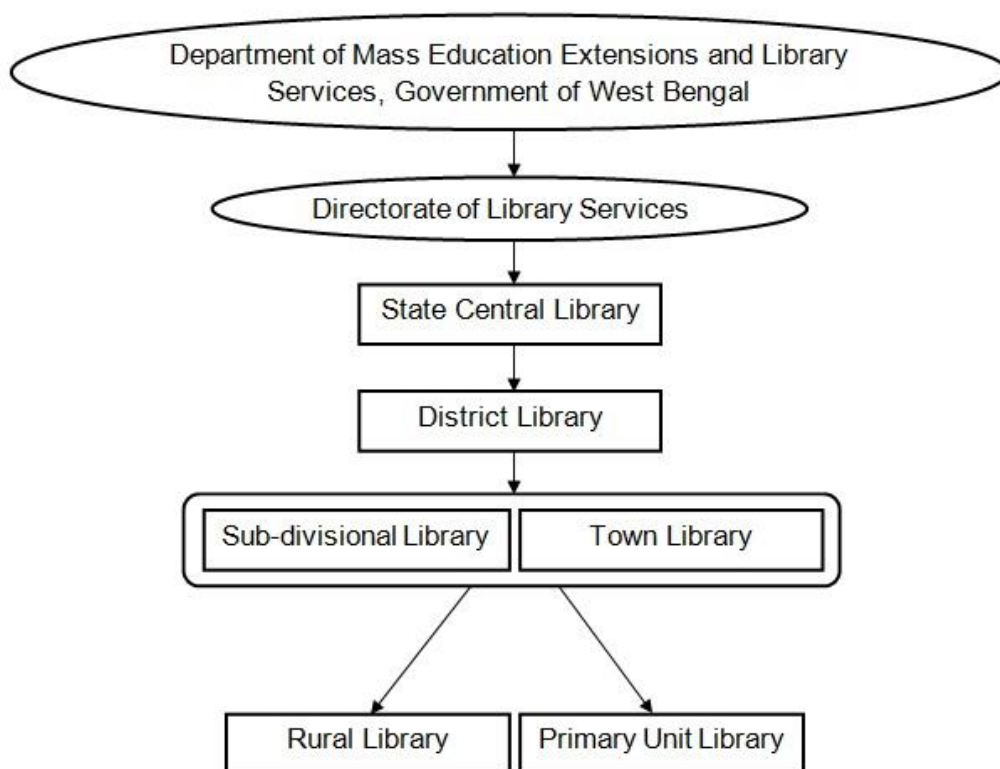


Figure 1: Hierarchical diagram of Public Library System in West Bengal

Sl. No.	Name of District	District library	Town library	PUL	Rural library	Sub divisional library	Others	Total no of public libraries
1	Bankura	1	6	3	119	1	0	130
2	Birbhum	1	9	3	110	1	0	124
3	Burdwan	3	18	25	163	3	0	212
4	Coochbehar	0	7	2	100	0	0	109
5	DaksinDinajpur	1	4	3	49	0	0	57
6	Darjeeling	0	4	2	88	2	3	99
7	Hoogly	1	22	14	121	0	0	158
8	Howrah	1	10	24	99	2	0	136
9	Jalpaiguri	1	9	13	85	0	2	110
10	Kolkata	0	8	83	0	0	4	95
11	Malda	1	8	4	91	0	1	105
12	Murshidabad	1	8	2	144	3	0	158
13	Nadia	1	9	11	87	0	2	110
14	North 24 Pgs	1	38	90	87	0	5	221
15	Paschim Medinipur	1	13	12	129	2	1	158
16	Purbo Medinipur	1	9	4	106	1	0	121
17	Purulia	1	4	0	111	1	0	117
18	South 24 Pgs	1	18	30	107	0	0	156
19	Uttar Dinajpur	0	3	4	45	1	0	53
20	SMP_AREA-DARJEELING	1	3	3	20	1	0	28
	Grand total	18	210	332	1861	18	18	2457

Table 1: District-wise distribution of different tiers of public libraries in West Bengal

Examining the statistical figures, as appeared in the official website of West Bengal Public Library Network (wbpublibnet.gov.in) under the Ministry of Mass Education Extensions and Library Services, Government of West Bengal, it appears that compared to the total number of public libraries in West Bengal, the number of public libraries where library automation has been introduced is very marginal. The district libraries and a section of town libraries, by virtue of their position in higher ladder under public library architecture, and of course, having increased volume of footfall, have received greater attention and therefore most of them have computerised their library system (Bandyopadhyay, 2008; Majumder, 2017; Maity, 2018; Munshi and Ansari, 2020). District libraries are directly connected to the State Central Library via public library network. However, town libraries have introduced library automation with library management software running on a standalone server, each installed in every town library. Rural libraries and PULs are mostly serving without library automation system.

1.2. A Brief overview of West Bengal, India

West Bengal, formerly the western part of Bengal Presidency under British India and presently the eastern state of Republic of India, carries the architectural, cultural and pluralistic essence over centuries extending across caste, creed and religion. The majorly Bengali speaking state of West Bengal harbours population from different Indian states with different mother tongues and houses several indigenous tribes in its western districts and northern districts. The agrarian state of West Bengal with wide vegetative region, experiencing differential rainfall, having diverse soil quality, in a geographic contour traversed by rivers, mountains, hillocks, plateaus and sea give the cosmopolitan nature of West Bengal a wider variety to reckon with. West Bengal borders other Indian states - Orissa, Jharkhand, Bihar, Sikkim and Assam in anti-clockwise geographical array. Most importantly, in its northern fringes, West Bengal shares international boundary with the Himalayan kingdom of Bhutan and in eastern front with the Republic of Bangladesh which makes it strategically most vital. The south of West Bengal meets Bay of Bengal which triggers the monsoon climate or the rainy season in eastern India during June -July, a special feature in world climate (Bhattacharya, 2018). Sunderbans in its southern fringes is famous for the world's largest mangrove forest with a wide variety of flora and fauna (Roy Chowdhury and Vyas, 2007). Historically, West Bengal happens to be the hub of British India with its capital Calcutta, now Kolkata is the state capital of West Bengal and bears testimony of India's freedom struggle (Heehs, 1988; Sen, 1997). West Bengal boasts the pride of setting up of the first university (University of Calcutta) and the first medical college (Calcutta Medical College) in South Asia. Several luminaries, passed out of colleges and universities in West Bengal, have distinguished themselves in diverse fields and earned accolades across the world. Examining the public library status of such a state and suggesting improvements in terms of ICT application therefore, deserves a special significance.

2. Literature Review

2.1 Emergence of cloud computing

Technological development and advancement of computing facilities make us strong receivers of more and more reliable, secure, easily adoptable, and burden free applications in our real time approaches. The term "cloud computing" was first revealed in public domain by "Google in 2006 to refer to a business model in which data service and architecture reside in remote servers" (Bogatin 2006 as cited by Su, 2011). During the next few years, the term "cloud computing" grew prominence among the major IT firms, e.g., HP, IBM, Amazon,

Microsoft, Fujitsu, etc., that started providing cloud based services extensively, with the opening of many cloud based avenues (Su, 2011). Cloud computing has three pyramidal sides, infrastructure as a service (IaaS), platform as a service (PaaS), and software as a service (SaaS) (Vaquero et al. 2009). Cloud computing, being an improved version over the cluster computing and grid computing, has its root with implementation and application delivery option that get actualised with more evolving technologies – virtualization, service-oriented architecture, utility computing, and autonomic computing intending to foster bigger resource accumulation (Smirnov, 2018; TYJ and Vadivu, 2019; Zandesh et al., 2019; Scalera, 2020).

2.2 Cloud computing in libraries

What makes cloud computing more attractive is its power of ensuring data security and savings in hardware cost. Cloud based applications are widely implemented in finance and commercial sectors, medical and healthcare and are gradually making inroads to educational sectors and to the field of library (Xue, and Xin 2016; Li and Liu, 2017; Ali, et al., 2018; Dang, et al., 2019; Darwish, 2019; Almarabeh and Majdalaw, 2019). Literature pertaining to the use of cloud applications in libraries, basically centered around describing the basic generalised models of cloud computing and describing the challenges and opportunities in adopting cloud computing in libraries (Romero, 2012; Li and Liu, 2017; Shen et al, 2017). In a very early study, Jane Cho, (2011) proposed a SAS based cloud model for libraries in Korea, however, the approach was theoretical with no simulation offered. Majority of the literature on cloud computing implementation in libraries are very descriptive and only focus on fundamental functionalities of cloud infrastructure, its storage, searching, security and the likes (Shen et al. 2017; Tzoc and Millard, 2017). Therefore, our study emphasising the need to use a cloud model embracing public libraries in different tiers to showcase enhanced functionality of the public library system of a geographical area, bears significance.

2.3 Cloud computing in libraries in India

Going by the immense opportunities they offer and with the deployment of many large applications on cloud platforms, cloud based applications are becoming more popular among Indian clientele (Kumar, et al, 2017; Gill, et al 2017). Among the diverse fields which intend to adopt cloud computing in India in recent times because of its ability to scale down the cost of hardware and software significantly, the education sector is one such sphere which deserves special mentioning. Since libraries are integral part of any educational institute to promote teaching, learning and research activities, involvement of library with cloud architecture seems imminent. Therefore, libraries in India are contemplating more inclination towards cloud based applications for improved library services in a secured and cost effective environment (Yuvaraj, 2016; Shaw and De Sarkar, 2019). The work of libraries, in terms of accessing e-resources, have become more simplified with publishers making their presence felt increasingly on cloud platform. Publishers of e-resources, aggregators and cloud based solution providers offer online research tools and applications along with discovery services on cloud platforms such as LSDiscovery, ProQuest Summon, Ex Libris, Knimbus cloud apps, etc.. All these providers have the same intent to expedite information discovery by users, allowing real time access to online journals, books, databases, archival resources and various research tools and most importantly access to digital repositories (Jayalath, 2014; Makori, and Osebe, 2016; Singh, 2016; Yang, et al, 2017)

2.4 Cloud computing in public libraries

Among the types of libraries, the academic and special libraries are attached to the parent bodies like educational institutes and commercial/ industrial units, etc., and are specially

governed by the rules as set by their respective parent bodies. The user groups of the above libraries are well defined and those user communities have fuller access to their respective libraries. However, a public library as the name suggests, is more pluralistic in nature and is open for all in the society and retains the public face of the library intending to build a strong bonding with the society, which indeed, no other kinds of libraries are supposed to offer. Therefore our study restricts itself on the public library system of a state in India. Keeping pace with the technological development across the globe, the traditional public library system needs a change in modern ICT enabled world. There are lots of studies on traditional public library services, guidelines, reading habits and impact on society, etc., (Joseph, 2009; Marcum, 2017; Koontz and Gubbin, eds, 2020), however, as such there is hardly any literature devoted to public library implementing cloud infrastructure with simulation. Accordingly our study aims at suggesting ways to implement cloud infrastructure over the existing public library system. We have chosen the public library system in West Bengal and proposed a public library cloud model architecture specific for the adoption of the West Bengal public library system to make the existing public library network more accessible to the user community. The reliability, data security, and affordability are factors for improved workflow in cloud based public library system. Since data security is one of the prime concerns in cloud technology, Susilo et, al (2021) in their most recent article stressed the need to implement more data encryption technology and stronger access control mechanisms.

2.5 Cloud based LMS applications

There are many cloud based library software available in the market. With the provisioning of harnessing cloud infrastructure, library management software providers such as LIBSYS develops LSCloud LMS solution (www.libsys.co.in). OCLC uses WMS (WorldShare Management Services) - a “complete cloud-based library management platform” providing an integrated solution supporting effective handling of physical and electronic resources in one platform (<https://www.oclc.org/en/worldshare-management-services.html>). WMS brings all participating libraries under LIBROS consortium, giving greater access control to policies, functions and services (<https://www.oclc.org/en/member-stories/libros.html>). The World Cat service of OCLC, the world’s largest cooperative venture of libraries providing union catalogue of bibliographic database, allowing users to search for books, is hosted on cloud platform. Alma by Ex Libris is an integrated library service platform that manages physical, electronic, and digital materials in a single platform (<https://exlibrisgroup.com/products/alma-library-services-platform/>). Cybrarian, a SaaS based integrated library automation solution offers librarians to manage their library data online, enabling the users of the participating libraries to locate the bibliographic data of their respective libraries from across the globe (<http://www.cybrarian.in/Default.aspx>). Koha, an open source software on cloud platform gives librarians the opportunity to adopt and customise it according to the needs of cooperating libraries. The detailed information on the features of Koha is available at <https://texicon.in/koha-on-cloud/>. The utility of cloud computing in different section of society is shown in Figure 2.

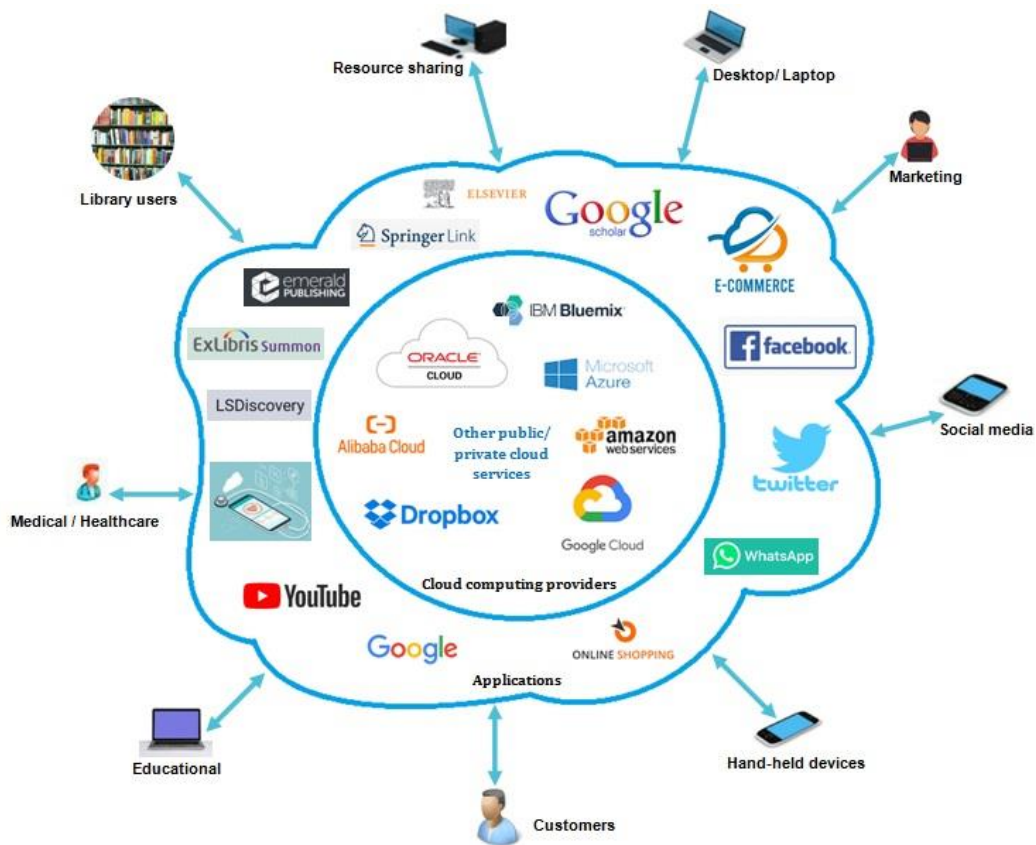


Figure 2: Utility of cloud computing

3. Approach

3.1 Rationale of the study

Cloud based library software solutions are available in the market, either proprietary or open source. We just need to have the initiative to choose a right model for implementing cloud computing on the existing infrastructure to bring network of libraries under an integrated approach for wider functionality. Since research on cloud computing in library in terms of model approach is very scarce and as there is no such model with simulation to particularly fit the existing public library network, we have developed a cloud computing model for the same. The state of West Bengal is chosen as a sample approach to delineate our cloud model.

3.2 Proposed cloud model

In our proposed model, we intend to cover all types of public libraries, forming the public library system in West Bengal including the rural and PULs, under a single library automation system based on web accessibility via internet. The model proposed a cloud infrastructure having software as a service (SaaS) architecture for all types of public libraries. Among the three types of cloud model, the SaaS model is more appropriate to connect rural and PULs with district and town libraries via the apex library called the State Central Library, since the library management system (LMS) software under cloud infrastructure can be accessible through web browser having connection with internet. Such implementation of cloud based LMS shall relieve librarians from installing vast computer system within the library, instead, they only require a computer with internet access and web browser to adopt networked library automation service in their libraries, to realise the benefit of library

automation in fuller length and action. The proposed model shall also drastically reduce the cost of implementation of ICT enabled library automation system across all types libraries compared to that of point to point network connectivity through LAN and WAN. The proposed SAAS based cloud LMS model for public libraries in West Bengal has been illustrated in Figure 3.

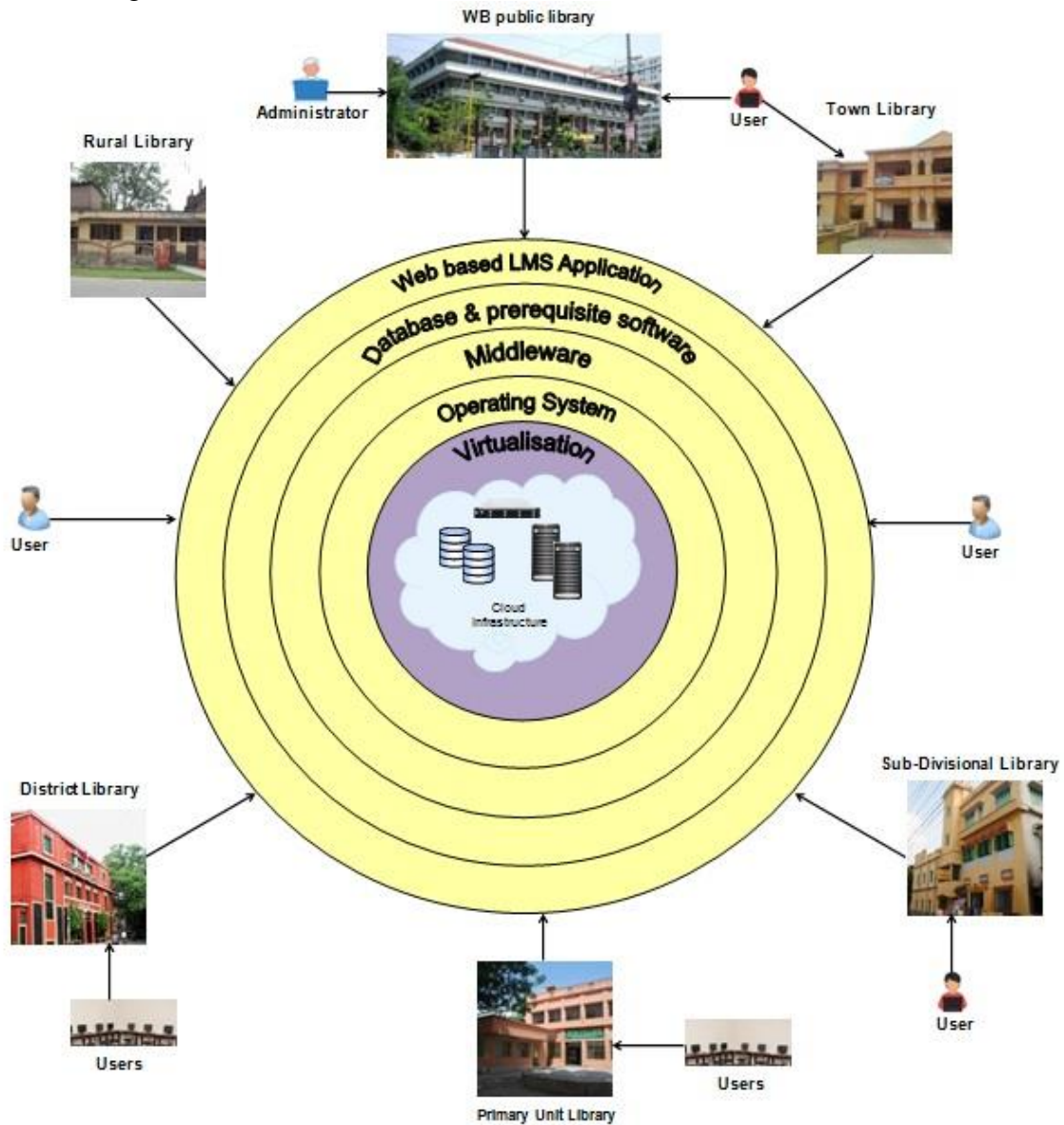


Figure 3: Cloud LMS model for public libraries in West Bengal

In the present system, as followed by the public libraries in West Bengal, the district libraries and most of the town libraries, those have implemented ICT in their libraries, run their library automation software independently on their standalone server. To run LMS software on on-premise based server connected with nodes in LAN, the minimum hardware requirement for each library is given below table 2. Since there are 18 numbers of district libraries and 210 numbers of town libraries in West Bengal, the requirement of hardware for implementation of LMS server is multiplied with the given number. Therefore, the minimum hardware required for the total number of 228 numbers of district and town libraries together is shown in table 2. Most of the rural libraries and PULs under West Bengal public library system are yet to be covered by library automation and networking. If these bottom tier libraries are brought under

the public library network, the hardware requirement for LMS server is needed to be multiplied with the total number of rural libraries and PULs together. Thus the total hardware requirement for the fuller adoption of library automation across all types of (2457 nos.) public libraries in West Bengal is furnished in Table 2:

Hardware requirements →	For each public library (A)	For altogether 228 numbers of district and town public libraries (A * 228)	For entire public library system i.e. 2457 numbers of public libraries (A * 2457)
Processor	02 nos.	456 nos.	4914 nos.
RAM	2 GB	456 GBs	4914 GBs
HDD Space	500 GB	114 TBs	1228.5 TBs

Table 2: Hardware requirement to automate the entire public library system in West Bengal

The above figure asserts that, in order to set up a fully automated public library system in West Bengal, the hardware involvement shall be enormous, which not only signals a huge cost of implementation but at the same time keeps the provisioning of recurrent expenditure, entailing hardware obsolescence with time and periodic maintenance. To reduce this cost of implementation and associated expenditure, and to bring all types of public libraries in West Bengal under a ICT enabled system, we propose a SAAS based cloud LMS model for public libraries in West Bengal. To migrate the existing public library system, including rural libraries and PULs to cloud platform, using SAAS architecture as proposed in our model, the hardware requirement will be reduced to 95% of the present requirement and the cost of implementation will also be reduced to the same proportion. The hardware requirement for the cloud based public library automation system is given below (Table 3):

Hardware requirements →	Cloud Data Centre for Public Libraries in West Bengal
Processor sockets	8 nos.
CPU core	32
RAM	256 GBs
Storage	100 TBs

Table 3: Minimum hardware requirements for West Bengal public library cloud infrastructure

A simple statistic will figure out that the numbers of processors required in the proposed cloud based LMS model for public libraries in West Bengal is just 0.7% of the total

requirement of the number of processors, which otherwise would have been required to implement traditional public library automation system in every library discretely. Similarly, the RAM and storage requirement for the cloud based LMS model are very marginal compared to that of the traditional LMS application. The required figure for RAM and storage in the cloud LMS being 2% and 8.14% of the total requirement under traditional LMS application. For more clarity a graphical and comparative representation of the hardware requirement in traditional public library system and cloud based LMS system is shown in Chart 1.

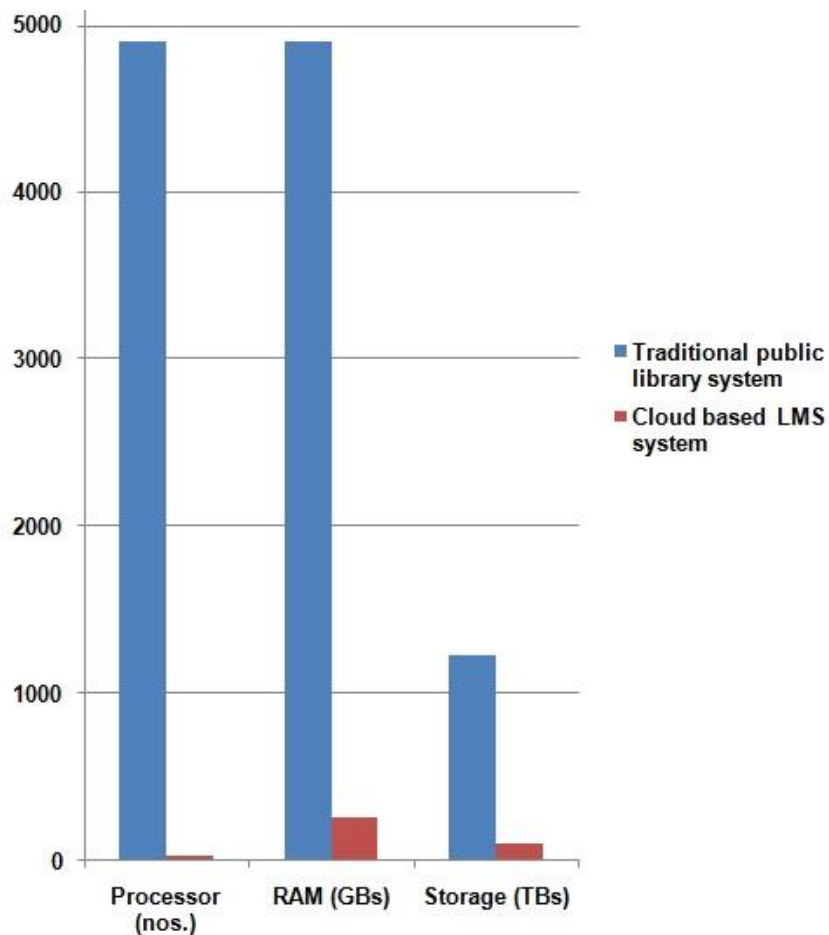


Chart 1: Comparative figure showing major hardware requirements in cloud LMS and traditional library automation among public libraries in West Bengal

The State Central Library, district libraries, sub-divisional libraries, town libraries, primary unit libraries, and rural libraries in West Bengal can access the LMS software in cloud platform by using public internet via web based authentication system. The State Central Library, being the apex West Bengal public library, shall reserve the administrative privilege to maintain and monitor the cloud based LMS system centrally and assign differential access rights to all types of public libraries in West Bengal according to their requirements and status. Any types of public libraries under SaaS based LMS system shall have the freedom to access different modules of library automation from their premises or from any geographical locations via internet.

In our cloud infrastructure model, the LMS application, together with the database, and the public internet, is secured by the fire wall that lies on our model at the interface.

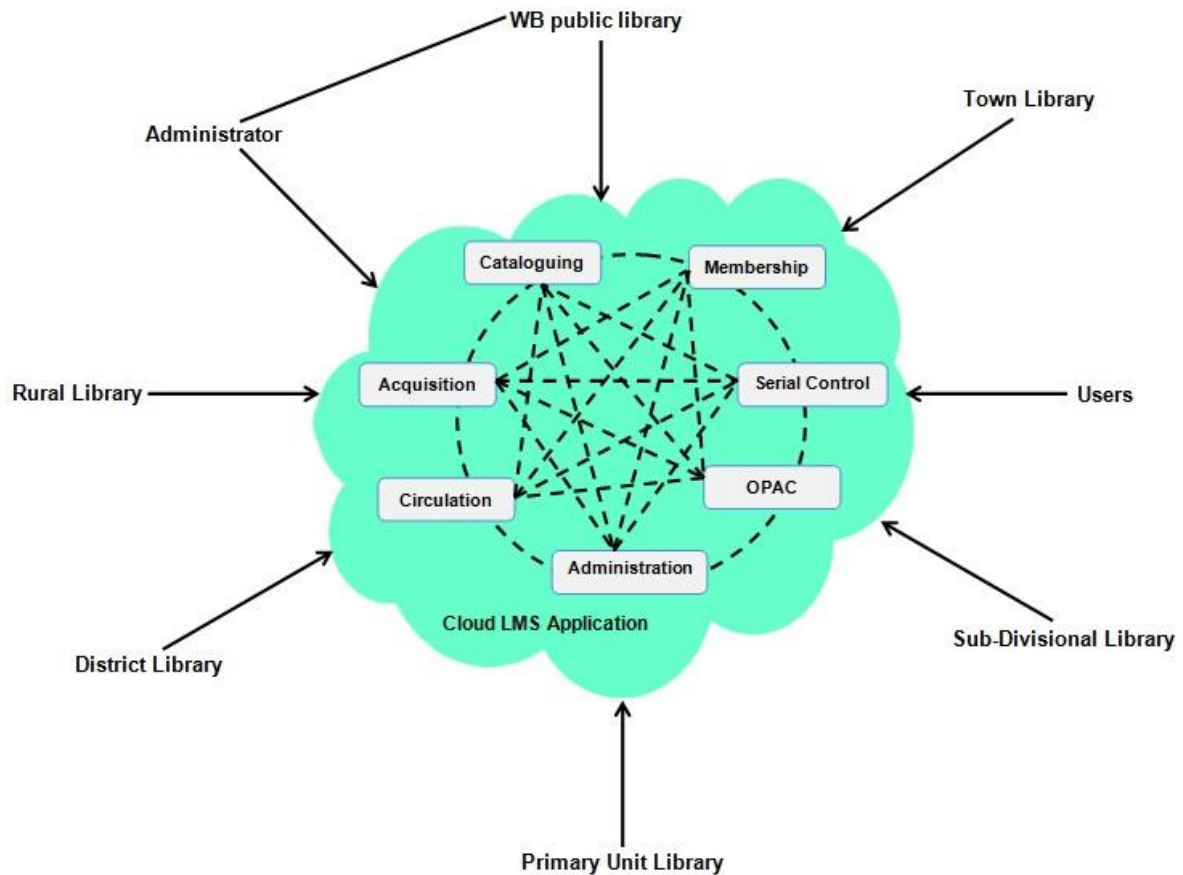


Figure 4: Cloud LMS delivery model for public libraries in West Bengal

The proposed cloud based LMS delivery model for public libraries in West Bengal is shown in Figure 4. In our proposed cloud model as shown in Figure 4, just one LMS application with backend database is required to work on SaaS model, such as KOHA, LibSys, WMS, Cybrarian, or any new SaaS based LMS software meeting public library requirements. Our proposed model with its mesh network link structure embraces all sorts of modules that library automation requires, such as cataloguing, membership, acquisition, serial control, circulation, OPAC, administration, etc. All public libraries can be connected with this mesh network having differential access to all modules depending on the access privilege as granted by the apex library, State Central Library. Therefore the proposed model enables different libraries under the public library hierarchical structure to access different modules and carry out their function remotely on a single platform. As the SaaS based cloud model uses only one LMS with a single database, all the libraries connected to the network shall use the same LMS and the same database for activities pertaining to modules like acquisition, circulation, cataloguing and most importantly the OPAC. Therefore the model enables the public library system of West Bengal to have one single and uniform OPAC for the bibliographic contents of the entire library system to be displayed at one platform.

3.3 Simulation

3.3.1 On Amazon AWS cloud platform: There exists several cloud service provider platforms, which provide different cloud service provision such as creating instances/virtual machines, all free for testing or simulation purpose. The Google cloud offers 90 days free trial or free tire monthly usage limits. The Amazon AWS provides 12 months free tire access to create EC2 instance i.e. virtual machine. Oracle cloud gives access to a wide range of Oracle Cloud services for 30 days free trial, including databases, analytics, compute, and container engine. Microsoft Azure cloud provides free developer tools for students.

For simulating, we used Amazon AWS compute cloud platform to our SaaS based cloud LMS model for public libraries. The Amazon Elastic Compute Cloud (Amazon EC2) is a web service that provides secure, resizable computing capacity in the cloud (<https://aws.amazon.com/ec2/>). First, we created a free AWS account for creating a free virtual server which runs our LMS server for public libraries. Thereafter, we created an instance or virtual server of Ubuntu Server 20.04 operating system using AWS EC2 service to run cloud LMS for public libraries. Out of several available Amazon Machine Image (AMI) or operating systems, we chose Ubuntu Server 20.04 LTS as an AMI base image. We configured instance details, storage, security group and then finally launched the instance `AWS_LMS_SERVER_PLIB` for public libraries. We connected the `AWS_LMS_SERVER_PLIB` virtual server using EC2 instance connect, which opens a CLI console for installation of application software. Using CLI console we installed open source LMS software KOHA, though KOHA has some limitations to be used in a fully SAAS based cloud software. The simulation process is shown in below Figure 5 and Figure 6:

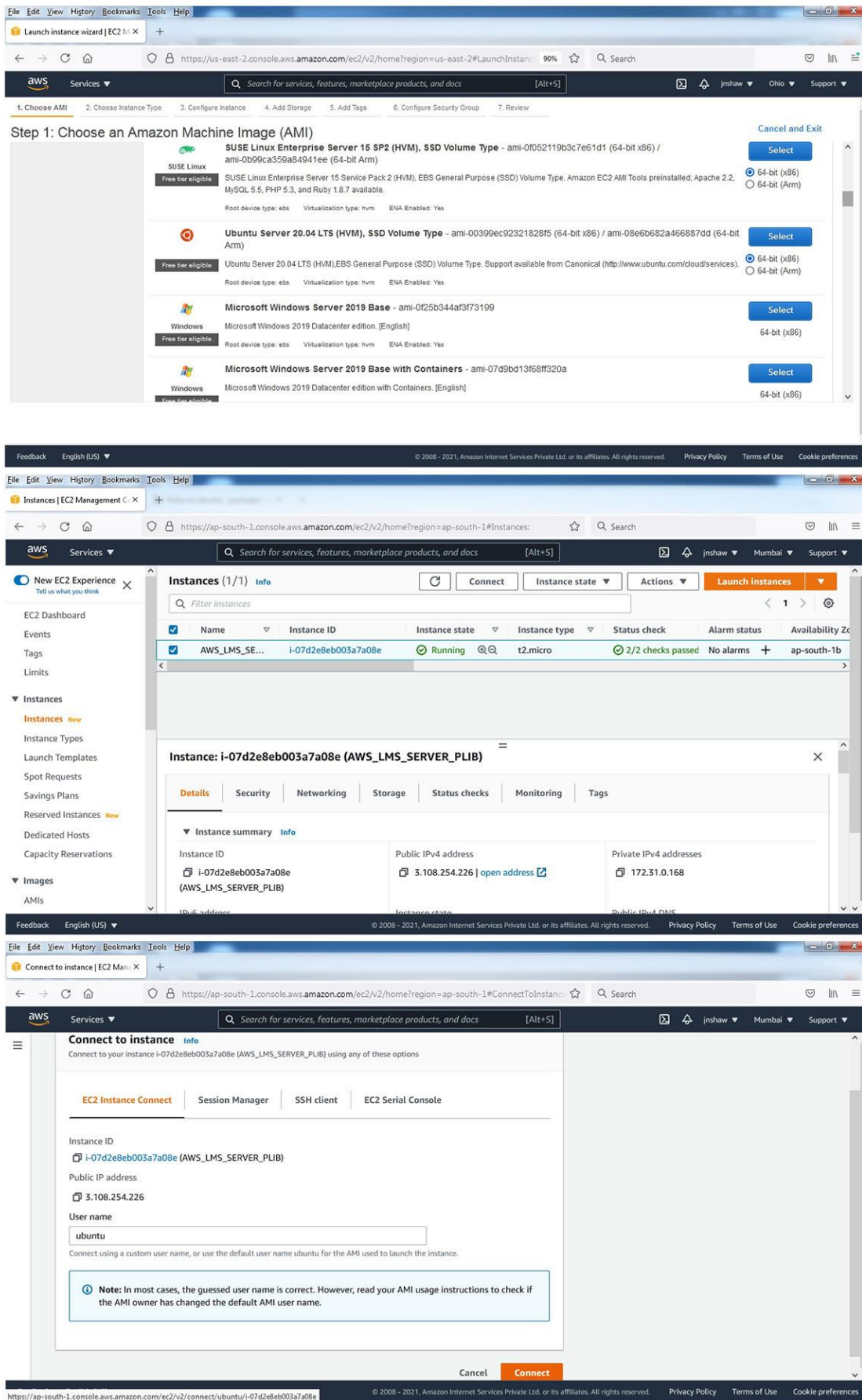


Figure 5: Simulation - On Amazon AWS cloud platform

```

Welcome to Ubuntu 20.04.2 LTS (GNU/Linux 5.4.0-1045-aws x86_64)

 * Documentation:  https://help.ubuntu.com
 * Management:    https://landscape.canonical.com
 * Support:       https://ubuntu.com/advantage

System information as of Thu Aug 19 13:49:45 UTC 2021

System load:  0.0          Processes:            100
Usage of /:   16.5% of 7.69GB   Users logged in:    0
Memory usage: 22%          IPv4 address for eth0: 172.31.0.168
Swap usage:   0%

1 update can be applied immediately.
To see these additional updates run: apt list --upgradable

The list of available updates is more than a week old.
To check for new updates run: sudo apt update

Last login: Thu Aug 19 08:55:38 2021 from 13.233.177.1
ubuntu@ip-172-31-0-168:~$

```

i-07d2e8eb003a7a08e (AWS_LMS_SERVER_PLIB)

Public IPs: 3.108.254.226 Private IPs: 172.31.0.168

```

Setting up mysql-server (8.0.26-0ubuntu0.20.04.2) ...
Processing triggers for systemd (245.4-4ubuntu3.11) ...
Processing triggers for man-db (2.9.1-1) ...
Processing triggers for libc-bin (2.31-0ubuntu9.2) ...
root@ip-172-31-0-168:/home/ubuntu# sudo mysqladmin -u root password koha!ms
mysqladmin: [Warning] Using a password on the command line interface can be insecure.
Warning: Since password will be sent to server in plain text, use ssl connection to ensure password safety.
root@ip-172-31-0-168:/home/ubuntu# sudo a2enmod rewrite
Enabling module rewrite.
To activate the new configuration, you need to run:
  systemctl restart apache2
root@ip-172-31-0-168:/home/ubuntu# sudo a2enmod cgi
Enabling module cgi.
To activate the new configuration, you need to run:
  systemctl restart apache2
root@ip-172-31-0-168:/home/ubuntu# sudo systemctl restart apache2
root@ip-172-31-0-168:/home/ubuntu# sudo koha-create --create-db libdb
Koha instance is empty, no staff user created.
 * Starting Koha worker daemon for libdb          [ OK ]
 * Starting Koha indexing daemon for libdb       [ OK ]
root@ip-172-31-0-168:/home/ubuntu# sudo nano /etc/apache2/ports.conf

```

i-07d2e8eb003a7a08e (AWS_LMS_SERVER_PLIB)

Public IPs: 3.108.254.226 Private IPs: 172.31.0.168

Figure 6 : Simulation - On Amazon AWS cloud

3.3.2 On standalone server

We have also created a SaaS cloud platform in a standalone server having two CPUs, 32 GB RAM, 16 TB harddisk. In our SaaS based cloud LMS for public libraries, the total cloud infrastructure is allocated to create a virtual server using VMware ESXi hypervisor followed by the installation of Red Hat Linux server. Thereafter we installed KOHA LMS application with prerequisites and MySQL database on Red Hat Linux server (Virtual machine) as a SaaS application for public libraries in West Bengal. KOHA LMS software is a web based open source application used for our SaaS based cloud application. The public libraries, thus connected through LAN with cloud LMS server can access KOHA application and database in order to create and upload library holdings of each public library. The architecture of SaaS based cloud LMS system for public libraries in West Bengal is depicted in Figure 7 and Figure 8.

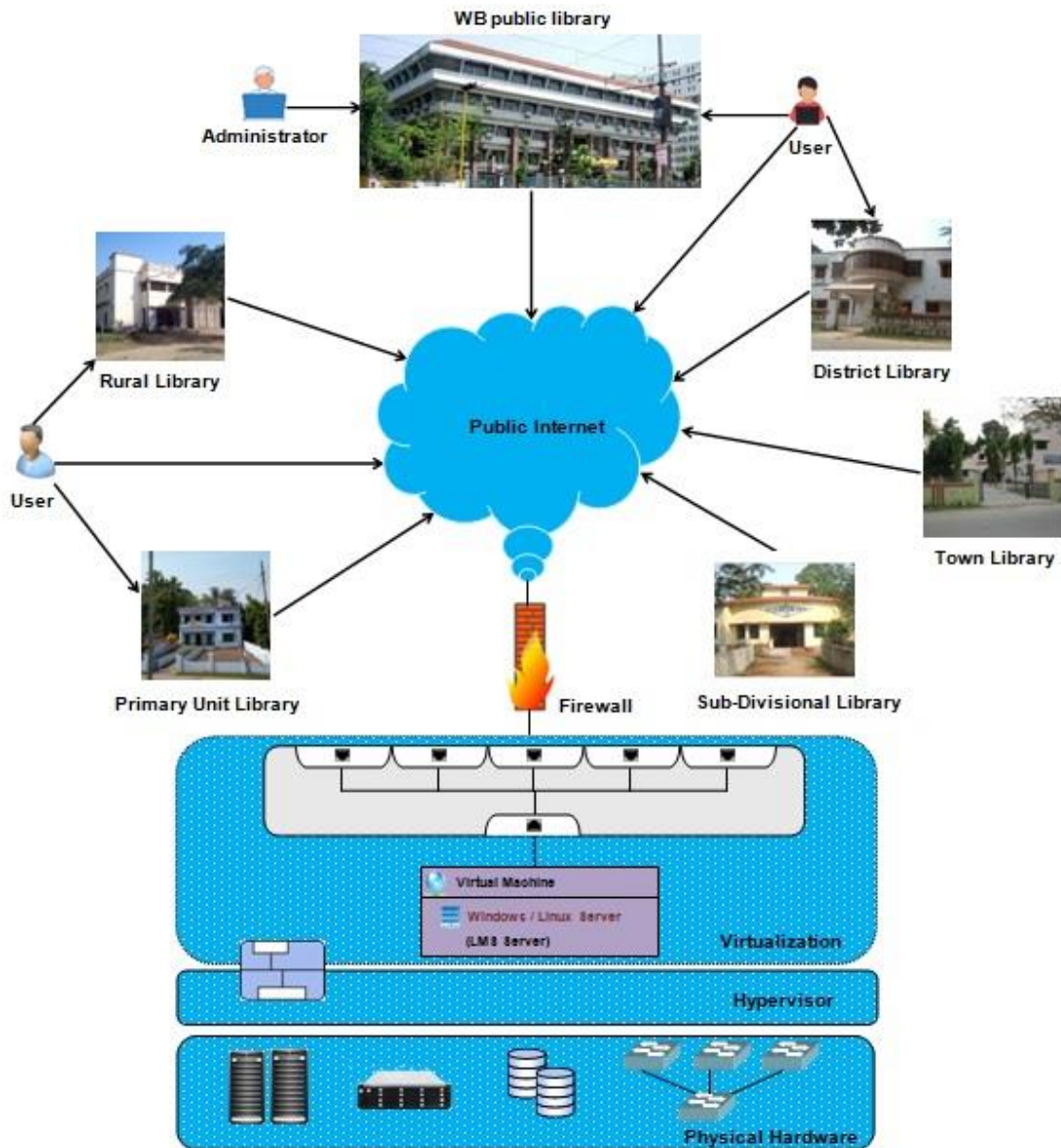


Figure 7: SAAS cloud virtualization architecture for public libraries in West Bengal

View: vSphere Standard Switch

Networking

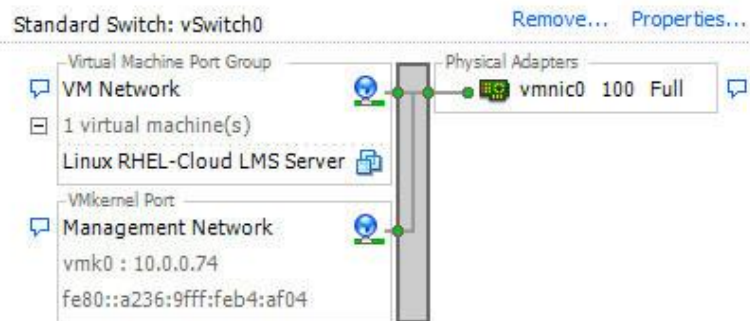


Figure 8: Simulation - On standalone server

4. Utility and limitation of the proposed cloud based LMS model

4.1 Easy to deploy

The State Central Library, the apex public library in West Bengal, may set up a cloud infrastructure as private cloud platform within its premises or on the cloud service provider's platform such as Amazon cloud server, Google cloud server, IBM cloud server, etc. Alternatively, the State Central Library may also set up a cloud based LMS system on public cloud environment of the cloud service provider. After setting up a cloud platform for public libraries in West Bengal, a cloud supported library LMS such as KOHA is required to be installed on the cloud infrastructure, which is accessible as web application via computers, laptops, mobile devices, etc., having internet connectivity.

4.2 Library authentication for secured access

Each library shall be authenticated with the assigned user name and password to get connected to the cloud LMS via internet connection. After authentication via user name and password, the librarians of public libraries, shall be able to do their in-house library work on the said platform, either from library premises or from any place via internet.

4.3 Union catalogue: As all the libraries are connected to a common SaaS based public library LMS system, they have the opportunity to enter catalogue data to a common catalogue database depending on the degree of authentication. Each library may access the same database via user name and password authentication for entry, edit and other relevant work of its library holdings only. While individual libraries shall have partial control over the union catalogue, the apex library has the total administrative control over the said cloud based union catalogue. The union catalogue so created, shall be accessible as OPAC for the entire user community from anywhere to give a clearer picture of the library holdings of the entire public library system in West Bengal.

4.4 Centralized acquisition system: There are some remote area libraries where fund utilization for book purchasing, following all the official procedure may not be always very smooth, due to various reasons. To expedite the process of book purchasing and to enrich their collection, a centralized procurement mechanism for those libraries may be initiated. In this case, the apex library may procure books for those libraries centrally and after acquisition on cloud LMS, may distribute those books to the stated libraries. Depending on the degree of man power available in different libraries, the SCL may undertake the book processing work of the procured books under different libraries and after updating the union catalogue may distribute those books to the libraries for which those were purchased. The process shall expedite the procurement of books and minimize the delay in book processing. Therefore, after acquisition and book processing, the bibliographic information are immediately made available to the respective library users though the cloud based union catalogue.

4.5 Minimising cost: Our proposed model shall relieve the librarians of public libraries from the burden of counting the escalating costs of server, hardware and software. They also remain free from the hassle of keeping regular data backup and supervising data security. Everything will be taken care of by cloud administrator and cloud service

provider. Therefore, our cloud based LMS model helps reduce cost and underpins factors leveraging improved library services.

4.6 Smoothing administrative work: The cloud LMS platform has the provisioning to resolve any issues relating to ICT implementation and application faced by any libraries across the public library network from administrative end of the apex library. The cloud based LMS software utility and updates are readily made available to the cloud installed LMS application as soon as those are released. Besides auto-updating facility, the cloud LMS application itself can be easily installed, having improved turnaround time, timely maintenance opportunity via a single point of contact.

4.7 Cloud-based Inter library loan: Since the OPAC on union catalogue gives details of all public library holdings, books not available in a library may be made available from any of the connected public libraries via inter-library loan facility on cloud LMS. Document delivery using soft copies/ scanned copies may be made via cloud LMS,

4.8 Union membership database: Union membership database of cloud LMS facilitates the apex library to generate a consolidated membership statistics of all public libraries as well as individual library-wise membership statistics centrally. It will give an overall picture of library membership pattern and user strength in different libraries which in turn will help budget allocation for book purchase and infrastructural development.

4.9 24x7 Availability: Accessibility to LMS application by the administrators, librarians and library users from even remote locations is possible with an uptime of 99.9% following industry standard.

4.10 Online reference service : Cloud architecture offers the scope to provide online reference service in a cooperative gesture. Suppose, a user of a library places any reference query, the question may be responded real time by any of the participating librarians, if the query is not specifically restricted to a particular library. The online chat box or ask a librarian apps for the purpose is immensely useful.

4.11 Notification for new additions and updates: Cloud platform instantly notifies users about the new additions of library books and journals, new events and activities. updated notification regarding library rules, policies, general notification, etc.

4.12 Online renewal: Online renewal facility for the books taken on loan by the users, will help them to avoid taking the burden to physically coming down to the library just because of renewal of borrowed items.

4.13 On cloud fees deposition: Library related fees, including overdue charges, etc., can be easily deposited using library cloud network. The service will bring more transparency to transactions and will help keeping records secure for future correspondence.

4.14 Database security and scalability: Database backups are regularly scheduled and are automatically enabled on the cloud. The deployment configuration at the cloud based

LMS system are subjected to upscaling and downscaling dynamically according to the requirements of users and staff libraries.

4.15 Resource sharing : Networked libraries could share their resources remotely, using the SAS cloud platform.

4.16 The apex library needs to create its own cloud data centre on the premises of the library or needs to hire a cloud infrastructure from the cloud service provider. The apex library also requires an expert IT professional to do the task such as installation, configuration, monitoring, trouble shooting, etc., related to providing cloud based LMS service to public libraries.

A high speed internet connection and sufficient computers are required in each public libraries.

Though the apex library is freed from purchasing servers and software to install standalone on-premise LMS servers to different libraries, one-time infrastructure cost is involved to setup a cloud data centre and recurring cost is required to maintain cloud data centre.

Conclusion

Our proposed SaaS based cloud model with LMS application having multifaceted features that has been discussed above, shall smoothen the functionality of the public library system of West Bengal, if adopted in its existing multi tier hierarchical structure. Being a secured platform, the cloud shall offer restricted access to the public libraries depending on the degree of access rights as permitted by the administrators at the apex library. In case of any issues, the cloud application can auto recover and restore itself without human intervention, relieving the librarians from any such trouble shooting exercises. Web based LMS application on cloud is more secured since it recognises operators based on authenticity. To impose more security on the cloud infrastructure, advanced level of security features may be introduced in due course of time to secure the LMS software as well as the database from unauthorised access / misuse at any point. Since more than 25000 libraries are supposed to access a single LMS application over the cloud infrastructure and one discrete database is supposed to run on our cloud model, the size of the database shall gradually grow beyond the level a computer processor could hardly manage. The huge data, may require some new processing technologies like Hadoop, Spark, etc., for managing Big Data, to be properly stored and retrieved in the near future. The Big Data technology, being widely used in healthcare, commerce and education sectors, may be used in managing library data with the provisioning to resolve issues relating to data inconsistencies and differential data formats. On the flip side, since the library related data neither belong to the category of classified one nor related to financial lexicon, the application of block-chain technology seems inappropriate here. Future research may be carried out to identify areas in cloud library application where, and how, improved security measures over the existing infrastructure could be installed. Moreover, to manage incremental growth of library data, future study may be conducted to figure out an appropriate and affordable technology to manage huge volumes of data. The

cloud based public library system may have a token presence on the social media. Which strengthens the network among users, professionals, and likeminded people for broader exchange of ideas, paving the way for community bonding. Our proposed model is designed on cloud architecture, suggesting how public library system in West Bengal could enrich its functionality with the implementation of such an affordable infrastructure. Since majority of the public library system, especially those in the developing and underdeveloped countries are not connected to cloud infrastructure, our proposed SaaS based cloud model may be adopted by any public library system with required local level of customization.

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