Emerald Insight

Library Hi Tech News
Cloud libraries
Mayank Yuvaraj

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Cloud libraries

Mayank Yuvaraj

Introduction

Greek mythology tells of critters plucked from the earth's surface and treasured as a celestial body in the sky. Analogous developments have erupted in the computing world where data, software, hard disk and platforms have been installed in the computer Cloud swept away from server rooms and desktop PCs. "The Cloud phenomenon is very real because of its position to drive technology, deliver usability and force standardization" (James, 2010, p. 179).

In general, Cloud computing has stripped the computing power from CPU and brought a shift in the geography of computation leading to delivery of computing power on the Web (online CPU). "The Cloud is the content bazaar of the Web" that is "massive" and "ignoring or prohibiting the Web is to prohibit electricity" (James, 2010, p. 179). The "*Cloud*" element of Cloud computing can be seen as an acronym that stands for C – *Computing resources*, L – that is *Location independent*, O – accessed via *Online* means, U – used as an *Utility* and D – on *Demand* availability (Yuvaraj, 2013). Cloud computing has infested the structure and functions of the library's trinity: books to e-books, users to virtual users and staff to virtual staffs. Under the ascendancy of technological developments, library services have underwent phenomenal changes taking the shape of Cloud libraries. This article is written with an aim to present the various shades of Cloud computing-enabled Cloud libraries, their needs, features components, major players, infrastructure as well as strategies of realization. A Cloud library in general is a fundamental transformation of the entire brick-and-mortar library which offers an auspicious opportunity to introduce Web-based dynamic library services. In a Cloud library, services are consumed and delivered over the Internet.

Cloud computing and libraries

There is an intellectual contention of varied interpretations regarding the implication of Cloud computing in libraries. Sadeh (2007, p. 307) feels that "the widespread adoption of web search engines and other Internet tools and services and the emergence of players such as Google Scholar and Windows Live Academic in the scholarly information-retrieval arena have reduced users' dependence on library support to fulfil their information needs". Vaquero *et al.* (2009) opines that Cloud computing and Web collaboration are two major concepts that underlie new and innovative developments in library automation. Cloud services allow for more optimal resource utilization, easier access and more effective cost reduction. Moreover, the "change in users' perceptions and their preference for Internet tools and services such as web search engines, e-mail, blogs, and RSS news feeds" (Sadeh, 2007, pp. 307-316) needs to be studied and then redesign library services.

Yang (2012, p. 6) asserts that "the Cloud-based new generation of integrated library systems (ILS) allow many libraries to share useful data, for instance sharing of full-text journal titles from electronic databases. Many libraries subscribe to the same database". Libraries have turned to huge capital investment in IT infrastructure for various online as well as subscription-based services. With these successes, libraries are motivated for using subscription-based IT infrastructure in the Cloud. "In the field of library automation there are several commercial suppliers already offering various adaptions of their products which make the use of the Cloud possible to a lesser or greater extent" (Romero, 2012, p. 112). According to Tomer and Alman (2011, pp. 59-60), Cloud computing is important in the context of LIS, as it has been embraced by many organizations, including OCLC, OhioLink, SirsiDynix and the Library of Congress, suggesting that this mode of computing will have a significant impact on the configuration, economics and, perhaps, the personal requirements of library computing in years to come.

Libraries are in a unique position to experiment with Cloud computing given their service-oriented mission and need to find appropriate solutions using limited resources. Fox (2009) observes that the goals of the organization will have an impact on their use of Cloud solutions. Fox further argues that libraries may be governed by the policies and regulations that dictate how they can use Cloud-based solutions. On the other hand, Yang (2012, p. 7) opines that "as Resource Description and Access, our new cataloging rule, will replace AACR2 and be implemented in the future; the new Cloud-based ILS will provide a unified approach to bibliographic data". Cloud computing is also going to change the practice of traditional reprographic services offered in the libraries. Khater (2010) argues that "with the development of cloud computing and the digitization of human knowledge, translation has begun to see major breakthroughs by moving from rule to statistical based translation algorithms. Any individual, application or device is now enabled to translate content in endless languages, facilitating communication and breaking a major barrier – language". There is a tremendous amount of enthusiasm around Cloud-based solutions and services (filtering, sorting, categorization and analytics to help users manage the vast repositories of both structured and unstructured information) as well as the cost-savings

and flexibility that they can provide (Rhoton, 2009).

Transition to Cloud libraries

Modern libraries to a large extent are built on technology. Post 1950, information technology became an integral part of library operations. The path-breaking change however to library services came with the use of Internet services (networking). This paved the way for services being accessed and delivered via the Web. This concept matured into Cloud services. These services are offered by hosting the data stored in a database in the Cloud.

The development of technology that brought significant effect over the libraries has been presented below (Figure 1): "Richard West and Peter Lyman have suggested a three-phase procession of the effects of information technology on organizations: modernization (doing what you are already doing though more efficiently); innovation (experimenting with new capabilities that the technology makes possible) and transformation (fundamentally altering the nature of the organization through these capabilities)" (Lynch, 2000, p. 60). To flesh out the genesis of Cloud libraries, there is a need to gauge the development of Cloud libraries along these lines.

Modernization of libraries

Initially, libraries were reluctant to go along with Information Technology,

but the changes in information-seeking behavior of library users precipitated its need. Implications of Information Technology in libraries led to automation of library operations, rise of electronic resources and databases followed by digital libraries. "Users who have had the experience of using Web 2.0 services like Wikipedia, Blogger, and Flickr etc. have already experienced Cloud computing, maybe unknowingly" (Abidi and Abidi, 2012, p. 79). "Furthermore, cloud computing remarkably boosts the learning ability of students. New learning approaches and strategies are now being used on a large scale" (Cenon, 2012). The quick development of Cloud libraries have been brought by the emerging computing technologies that are offering reasonably priced metered usage of computing infrastructures and massive storage capacity.

Transformation of libraries

Modern libraries are largely driven by technology. Prior to the Internet, library networking was limited to cross-linking services between libraries. Post Internet, library networking has taken on a much more fundamental service role because it has become the library service itself, as physical services become virtualized. Commenting on the future of Cloud computing in libraries, Carl Grant at the ALA annual conference in Anaheim opined that "these new Cloud-computing platforms are the

technological foundations of that great age of librarianship. They're going to let us define new and better librarianship based services that will truly give us the capability to differentiate ourselves from other information end-user services".

To understand the nature and characteristics of Cloud computing-driven Cloud library, there is a need to demarcate the boundary between traditional brick-and-mortar libraries with that of a Cloud library. A comparative take on both of them is presented below (Table I).

Promises of Cloud libraries

Before switching to any new technology, one should look for the promises it can offer to its clients. A Cloud library offers following promises:

- transaction processing of resources and services that is reliable;
- availability of computing services as a commodity;
- scalable Web services and Web servers;
- integrated applications with open accessibility;
- cuts operational and capital costs;
- facilities to develop niche critical applications;
- frees library personnel to focus on delivering services rather than maintenance; and
- greener IT practices which result in more efficient power consumption.

Cloud library components

A Cloud library essentially comprises three components: client server, the data center and distributed servers. Client servers interact with Cloud libraries to seek information on the Cloud and are of three types. Thick clients use Web browsers to access the information in the Cloud. Users can even store their information on their hard disks or memory. Thin clients let the servers hosted in the Cloud do all the work to seek information from the Cloud. Mobile clients include devices like smartphones and tablets to seek information from the Cloud.

Data centers are a collection of servers that house the applications or that a library subscribes to. There are

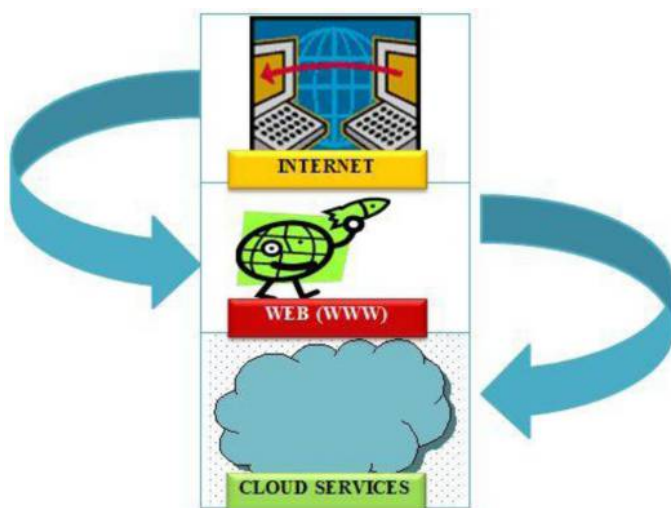**Figure 1.** *Development of Cloud technology*

Table I

Brick-and-mortar versus cloud library

No.	Brick-and-mortar library	Cloud library
1	They are available in-house	They are available virtually
2	Network connectivity is desirable to access the resources of this library	Network connectivity is essential to access the resources of this library
3	They are available to a local population to a specific group of users	They are available for a larger population irrespective of geographical location
4	They are dependent on software and hardware	They are independent of software dependency but are hardware dependent
5	They involve large extent of physical maintenance like dusting, fumigation, binding, chemical treatment, etc	They do not require any physical maintenance
6	They contain print as well as digital documents	They contain only digital documents
7	In this library, librarian has to focus on library services as well as computer-based services like (library automation and digital library)	In this library, librarian has to only focus on services not on any aspects of IT
8	There is no such loss of data	There is a greater risk of data loss so data has to kept as back up
9	There is always growth of library documents and requires expansion of library building	It does not involve physical storage or library building but needs database storage capacity
10	For availing the services, user has to come to library	It brings the information to the user which can be accessed by any device having Web browser via Internet
11	In this library, the library staff interacts face-to-face with the library user	It involves virtual interaction with the library user through social networks and blogs
12	The services of this library can be accessed by the devices available in the library only	There services can be accessed by any device that has a Web browser and has a network connection

two types of data centers: private or enterprise data centers and public or Internet data centers. A private data center is owned by the organization and provides the Web-hosting, applications and storage functions needed to maintain full operations. Public data centers are managed jointly by the public. Through public data centers, applications are typically accessed through the Internet; they vary with each other in terms of bandwidth type, use of layers in traffic control, extent of server virtualization and the number of servers.

With distributed servers, all the servers need not be housed in the same location. The existence of servers depends on the size, speed of physical server and the applications that are supposed to run on a virtual server. However, users get the feel that all the servers are working next to each other.

Categories of Cloud libraries

There are no fixed principles or built guidelines for the preconditions of a Cloud library. Using the constructive research method, I used the current state of the art on Cloud computing to produce a conceptual schema of Cloud libraries. There can be four categories of Cloud libraries:

(1) *Open Cloud library model*: In an open Cloud library model, implementation is jointly owned and maintained by the public with a wide array of services. These libraries are owned and managed by any business enterprise which charge for Cloud services.

(2) *Closed Cloud library model*: In a closed Cloud library model, access is restricted to internal users, such as to particular library patrons and staff. These services stay within a firewall.

(3) *Centrally funded integrated Cloud library model*: In this model, implementation will depend on the parent body, usually a government agency for its design and maintenance. Libraries have almost the same funding agencies as well as share a common user group who requires similar services. Under these cases, an integrated Cloud library has the utmost potential to reach out to its readers in the Cloud and develop global search mechanisms.

(4) *Publisher's Cloud library model*: The digital age has offered end users with a new, diversified and multi-sensory environment, where they can communicate freely and express themselves more fully through multiple electronic resource channels. These channels include e-books, e-journals, electronic dissertations and theses which are owned and controlled by a publisher or third party. Libraries can provide access to these resources through digital handwriting, voice prints, finger prints and access tokens to limit access.

Cloud library infrastructures

Many scholars have called the concept as hype and questioned the verity of Cloud libraries. Nonetheless, as personal computing brought decentralization that enabled users to run software of their own choice, Cloud computing provides users with the infrastructure and empowerment to run Web-based software and applications. The schema of creating a Cloud library infrastructure is presented below (Figure 2).

Because these services run Web-based applications or programs, it is indispensable to understand how a

Figure 2. *Cloud Library typical infrastructure*
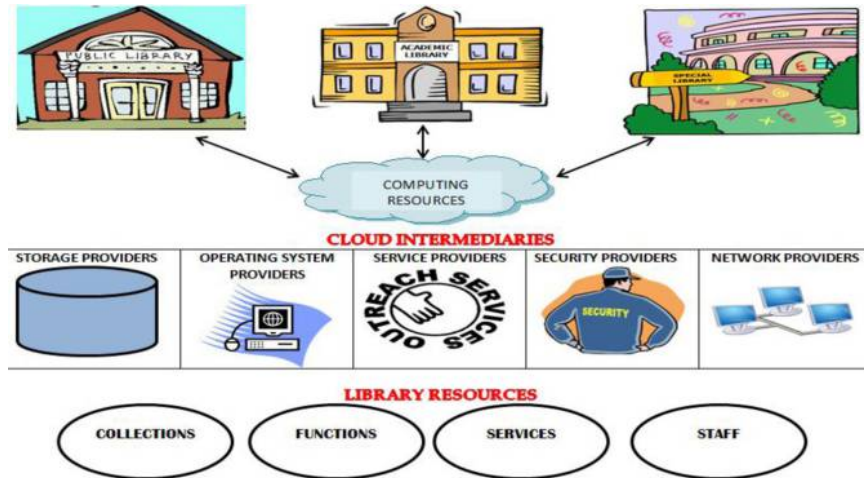
library can move into the Cloud. For creating such a service, any library has to depend on computing resources available in the Cloud. These computing resources are owned and provided by Cloud intermediaries.

Cloud storage, operating system and service providers

A Cloud storage provider offers organization and users with an infrastructure to store and save their data on online hard drives. The data in these hard drives are stored in distant data centers. The stored data can be accessed from any place that has network connectivity.

When selecting a Cloud storage provider, librarians should not necessarily look for companies offering services at a cheap rate. Librarian should instead analyze features, such as storage space, data uploading and downloading speeds and reliability. Then, features like backups (automated or scheduled), file- and folder-sharing facilities as well as data restoration should be looked at. Finally, the Cloud storage infrastructure should be easy to use and supplemented by phone, email, chat and video tutorials.

Cloud operating system providers enable the end user connected to the Internet to run various bits of software and desired applications. Any user at any time can run the software through the Internet from a Cloud server. Cloud operating systems have eradicated the technical configuration ensuring painless IT operations. Librarians

should comparatively evaluate the price of the operating systems in terms of subscription (either on use basis or any subscription plan, inbound and outbound bandwidth prices, plan costs per hour and any additional IP costs). Then, the features in terms of paid and freely available should be weighed. Auto scaling, load balancing, monitoring, root accessibility along with file and Web-hosting services should be given principal importance. Also, consider compatibility of operating systems, processor speeds and support of programming languages (Java, PHP, Ruby and others).

Cloud services providers offer users with services that can be private, public and hybrid (public + private) networks. It offers some components of Cloud computing – Infrastructure as a Service (IaaS), Software as a Service (SaaS) and Platform as a Service (PaaS) – to other individuals or organizations. An example of a Cloud service provider is the Amazon Elastic Compute Cloud (Amazon EC2) that provides end users with resizable computing capacity in the Cloud verified by Amazon. In selecting a Cloud service provider, librarians should take into consideration price, storage space, emails, contacts, calendars, documents editing, music- and video-playing support as well as slideshows creation and presentation facilities and that the services are accessible by all Web-enabled devices and configurations, as well as support.
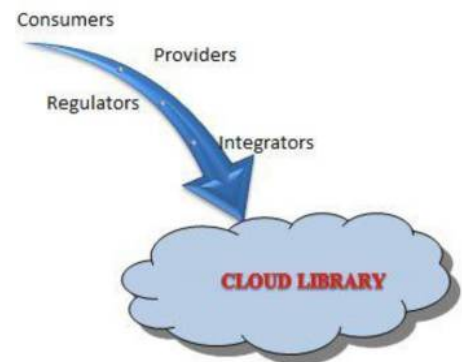
Cloud security

Library work involves large data due to which security perceptions are still the biggest obstacle to wider adoption in libraries. Cloud security providers attempt to keep the Cloud infrastructure secure, safe and protected. For selecting a Cloud security provider, librarians should check out the range of scalability and control offered, processing speed, disk space allocations, availability of SSD storage and the bandwidth, the use of unlimited firewall zones, Web application protection, network isolation, secured access to a virtual private network (VPN) and that it offers the features of data backups and third party application support.

Players of Cloud libraries

There are four categories of players that play important role in the Cloud library paradigm (Figure 3).

(1) *Cloud infrastructure consumers*: The library purchases the infrastructure and hosts its databases on the Cloud service provider's server. Users can access this infrastructure through any Web-browser-enabled device.
(2) *Cloud infrastructure providers*: A Cloud infrastructure provider owns and controls Cloud computing systems to deliver services (Software, Platform or Infrastructure) to libraries.
(3) *Cloud infrastructure integrators*: The role of Cloud infrastructure integrators is to collaborate to bring their services to new customers that may have not achieved expertise in Cloud.
(4) *Cloud infrastructure regulators*: Lillard *et al.* (2010, p. 9) state that

Figure 3. *Players in the Cloud library environment*

"Cloud computing comes with its own set of standards, terminology and best practises that can be difficult to manage within the traditional information security context". Although the Cloud computing industry does not yet have any regulatory body, it is being governed by Internet regulations. Still, operations face problems like data security, ownership, location, privacy and intellectual property.

Conclusion: cloud librarians and challenges and opportunities of Cloud libraries

Cloud librarians are a new genus of librarians; a group of highly skilled and competent professionals who can work in a Cloud landscape and nurture Cloud libraries. A Cloud librarian should maintain his or her virtual profile by creating a blog or social network profile to interact with their user community. The same platform can be used for providing reference services and educating users on Cloud resources or how to use the Cloud infrastructure. A Cloud librarian should have command over managing each and every aspect of Cloud library services irrespective of their work in a library section, have troubleshooting abilities and be well equipped of the devices used in the Cloud.

Although Cloud computing is a low-cost solution for organizations like libraries, it suffers from a number of limitations.

- Cloud libraries require a globally integrated Cloud infrastructure which is difficult for multilingual information resources.
- There is high uncertainty of storing the information on hard disks in the Cloud.
- Unavailability of library intermediaries in a Cloud environment affects the information competency of the users.
- Cloud libraries largely depend on high-speed network connectivity.
- There is concern regarding proprietary data held by a Cloud service provider.
- Most of the Cloud service providers offer a single pattern of *Terms* and *Conditions* for every user and will not

negotiate with individual users or libraries.
- Data retention or permanence in the Cloud

Any technology is often easy but people are hard to adopt because the processes are hard. As discussed earlier, there has been a drastic change in users who prefer information in the Cloud at their home. Some of the central issues for Cloud libraries that need to be worked out in the future are: legislation and regulation, expenses and budget justification, defining the scope and boundaries of the library services in the Cloud, data trust, privacy, migration and backups and competencies for Cloud librarians.

The Cloud library paradigm is all about virtualized Web-based services and providing easy-to-access and economic computing to users and librarian. Cloud computing is still evolving and in a state of flux. New players are constantly joining the Cloud race and everyone is using some form of Cloud unconsciously. There is a rapid shift of moving traditional library IT practices to leverage library services on Cloud platforms.

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Mayank Yuvaraj (mayank.yuvaraj@gmail.com) is based at Central University of Bihar, Patna, India.

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1. YuvarajMayank Mayank Yuvaraj Central University of South Bihar, Patna, India . 2016. Determining factors for the adoption of cloud computing in developing countries. *The Bottom Line* **29**:4, 259-272. [Abstract] [Full Text] [PDF]