Application of cloud computing in library management: innovation, opportunities and challenges

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1. Introduction
Traditionally, the Information Communication and Technology (ICT) devices are expensive in terms of their installation, configuration, manpower and in-house annual maintenance. In modern library management, the amount and variety of required hardware and software to run in own server are not easy task and need a subject expert in library to install, configure, debug, test, run, update as well as security measurement in respect of malfunction. These numerous challenge has been occurred everywhere in modern library where library initiates the automation. This may be called pre-cloud model of library automation.

In cloud based model, the overall computer hardware, software and their working nature will now dramatically change and simply in cloud computing, the library data will be stored over the Internet instead of hard drive in library server.

The cloud system is the future of Internet based service and in library management it will be dominated overall services of library. The present paper will be explored the significant of cloud computing in terms of applications use, opportunities regarding user services and challenges in respect of data management and retrieval over the Internet based platform worldwide.

2. What is cloud computing?
The authentic definition of cloud computing is slightly ambiguous, reason is that the whole structure of communication technologies, Internet models, computer hardware connotations have been interpreted in a single cloud computing system. The giant e-commerce platform Amazon and colossal search engine Google have given a indigenous cloud computing implementation worldwide.

If we will understand their cloud computing services, we can easily comprehend that “a cloud computing is on-demand access to virtualized Information Technology (IT) resources that are housed outside of clientele data center, shared by others, simple to use, paid for via subscription and access over the web”

However, above definition just articulate the overall structure of cloud computing in terms of its broadness. For example, what about the requirement that everything is provided “as a service over the Internet”

If we think its expansiveness, a team at the National Institute of Standards and Technology (NIST) has been defined in express way as "cloud computing is a type of computing that provides simple, on-demand access to pools of highly elastic computing resources. These resources are provided as a service over a network (often the Internet), and are now possible due to a series of innovations across computing technologies, operations, and business models. Cloud enables the consumers of the technology to think of computing as effectively limitless, of minimal cost, and reliable, as well as not to concerned about how it is constructed, how it works, who operates it, or where it is located."

The above definition clearly articulates what anyone outside of computing really needs to know when trying to understand what to make of cloud, and how it may impact their own operations.
Therefore, cloud computing can be defined as new style of computing in which dynamically scalable and often virtualized resources are provided as a service over the Internet and indeed cloud computing has become a significant technology trend, and many experts now expect that cloud computing will reshape IT processes and the IT marketplace. With the cloud computing technology, users use a variety of devices, including PCs, laptop, Smartphone, and PDAs to access programs, storage, and application-development platforms over the Internet, via servers offered by cloud computing providers and advantages of the cloud computing technology include cost saving, high availability and easy scalability.

3. Layers of computing

Figure 1 (Three layers of computing)


Figure 1 depict that three layers model of computing as a pyramid shape recognized a hierarchy of bottom to top significance of computing with infrastructure at the bottom, the platform in the middle and software at the top.

This three layers model of computing can be applied to cloud computing, but there are significant differences as comparison with conventional computing system, such as

3.1 Software applications are not desktop applications, they are web-based, so they can be used in any up-to-date web browser on any computer OS.

3.2 Platforms are purpose-build software development environments that are hosted on the Internet rather than desktop computer, so users need is a web-browser to create, test and deploy web applications.

3.3 Infrastructure elements (server, storage, bandwidth, processing power, etc.) are provided by a third party; but we can access and use these computing resources as if they were installed on own corporate network.

This cloud model of computing promotes availability, accessing, virtualization on cloud based computer environment where user can able to interact with software through platforms and infrastructure.

NIST defined five essential characteristics, three delivery service models, and four deployment models for cloud computing and draft definition goes on to five essential characteristics (on-demand self-service, broad network access, resource pooling, rapid elasticity and measured services), three delivery service models (software as a Service-SaaS, Platform as a Service-PaaS and Infrastructure as a Service-IaaS), and four deployment models (private, community, public and hybrid cloud).

Cloud computing is the next stage in evolution of the Internet. The cloud in cloud computing provides the means through which everything- from computing power to computing infrastructures, applications, business processes to personal collaboration; can be delivered as a service wherever and whenever need.

The cloud itself is a set of hardware, networks, storage, services and interfaces that enable the delivery of computing as a service. Cloud services include the delivery of software infrastructure, and storage over the Internet (either as separate components or a computer platform) based on user demand.
A fundamental concept of cloud servicing is that, the end user does not really have to know anything about the underlying technology. In library for example, the cloud provide becomes the de facto data centre, and cloud service provider is responsible for IT assets and maintenance.\textsuperscript{vi}

4. Cloud delivery service model:

A cloud delivery service model represents a specific, pre-packaged combination of IT resources offered by a cloud service provider and IaaS, PaaS and SaaS, these three common cloud delivery models have become widely established and formalized\textsuperscript{vii}. However, these three delivery models all differ with respect to both the functionality and the level of administrative control they provide to cloud users. Figure 2 presents the cloud computing delivery reference model, showing the interdependence between each model and the resource layers\textsuperscript{viii}.

These three models are interrelated in how the scope of one can encompass that of another.\textsuperscript{ix}.

4.1 IaaS

The Infrastructure as a Service(IaaS) offers storage and computer resources that developers and IT organizations use to deliver custom/business solution. IaaS is the delivery of computer hardware(servers, networking technology, storage, and data centre space) as a service. It may also include the delivery of OS and virtualization technology to manage the resources. Here, the more important point is that, IaaS customers rents computing resources instead of buying and installing them in their own data centre. The service is typically paid for on a usage basis. The service may include dynamic scaling, so that if the customers winds up needing more resources than expected, they can get them immediately\textsuperscript{x}.

The administrative controls of IaaS are as follows:

- The cloud provider generally has full control over all aspects of the physical infrastructure provision, such as the data center facilities and physical hardware (network, storage and server devices).
- The cloud provider has administrative control over the virtualization platforms.
- The cloud consumer has full or partial control of virtual servers, databases, and other infrastructure.
- The cloud consumer has full or partial control of VM(virtual machine) configuration, implementation, and other local setting including security levels\textsuperscript{xii}.
- A choice of ready-made virtual machines with pre-installed OS including numerous versions of Windows, Linux and Solaries.
- A choice of virtual appliances-virtual machines with specific sets of software pre-installed.
- Ability to store copies of particular data in different locations around the world to make downloads of the data as fast as possible.
- Ability to automatically scale computing resources up and down in response to increases and decreases in application usage.\textsuperscript{xii}

4.2 PaaS

In addition to infrastructure-oriented clouds that provide raw computing and storage services, another approach is to offer a high level of abstraction to make a cloud easily programmable, known as Platform as a Service (PaaS). A cloud platform offers an environment on which developers create and deploy applications and do not necessarily need to know how many processors or how much memory that applications will be using. For example, Google App Engine is...
a PaaS, offers a scalable environment for developing and hosting web application\textsuperscript{xx}. The administrative controls of PaaS are as follows:

- The cloud provider has full control of all aspects of the infrastructure provisioning.
- The cloud consumer has the requisite limited administrative control over the ready-made, pre-defined environment, such as the application server, middleware, and database\textsuperscript{xxi}.
- Browser-based development environment for creating databases and editing application code either directly or through visual, point-and-click tools.
- Built-in scalability, security, access control and web service interface.
- Tools for connecting to applications outside the platform’s cloud.
- Tools for designing web forms, defining business rules and creating workflows\textsuperscript{xx}.

\subsection{4.3 SaaS}

Applications reside on the top of the cloud delivery model. Services provided by this layer can be accessed by end users through web portals. Therefore, consumers (users) are increasingly shifting from locally installed computer programs to on-line software services that offer the same functionality. ILMS and other applications software can now be accessed as a service in the web. This model of delivering applications, known as SaaS (Software as a Service), alleviates the burden of software maintenance for customers (users) and simplifies development and testing for providers.\textsuperscript{xxii}

In user concern, SaaS is definitely an important service in terms of data accessing, collaborating, editing, storing as well as document sharing. The most popular and familiar example of SaaS is e-mail service in web browser, but SaaS applications are becoming increasingly sophisticated and collaborative\textsuperscript{xxii}.

In terms of library management, the entire library administrative works, user oriented services, documents delivery, e-accessing, management of e-consortia, etc. can be easily functioning on SaaS.

The administrative controls of SaaS are as follows:

- The cloud provider typically has full control over all aspects of application based infrastructure provision.
- The cloud provider often has some administrative control over the service implementation. This sharing of responsibility with the cloud provider is useful for the cloud consumer (user).
- The cloud consumer (user) has full usage control over cloud services.
- The cloud consume (user) only has the requisite limited control over the implementation of services as required by the provision, in order to enable integration with existing applications and correct configuration.\textsuperscript{xxii}

\section{5. Application Programming Interface (API) versus cloud system:}

In computer programming, an Application Programming Interface (API) is a set of subroutine definitions, communication protocols and tools for building software. In general terms, it is a set of clearly defined methods of communication among various components. An API may be for a web-based system, OS, database system, computer hardware, or software library and an API specification can take many forms, but often includes specification for routines., data structure, object classes, variables, or remote calls.\textsuperscript{xx}

SaaS offers many potential advantages over the traditional models of API software regarding installation, configuration, and accessibility, because in SaaS, the user does not pay for the software itself. Instead, it works like a rental. They have the authorization to use it for a period of time and pay for the software that they are using.\textsuperscript{xv}

There are following advantages of SaaS over API based model.

\subsection{5.1 Reduce time to benefit}

Different from the traditional model, in SaaS software almost preconfigured for the customers (users). the user has the advantage of provisioning the server for an instance in cloud and in a couple hours, they can have the application ready for use. This reduces the time spent in installation and configuration, and can reduce the issues that can get in the way of the software deployment.\textsuperscript{xxii}

\subsection{5.2 Lower up-front cost}

SaaS is generally subscription-based and has no up-front licence fees resulting in lower initial costs. The SaaS provider manages the IT infrastructure that is running the software, which brings down fees for hardware and software maintenance.\textsuperscript{xxiii}

\subsection{5.3 Easy upgrades}

SaaS provides upgrade the solution and it becomes available for their customers (users). Costs and effort associated with upgrades are lower than the traditional model (API) that usually forces the user to buy an upgrade package and install it, or pay for specialized services to get the environment upgraded\textsuperscript{xxiv}.

\subsection{5.4 Compatible across multiple devices}

Location is not the only advantage of SaaS when we consider accessibility. This type of software distribution model enables a user to access it from distinct devices. Therefore, it is even more convenient for a client to exploit software\textsuperscript{xxv}.

\subsection{5.5 Scalability}

SaaS provides generally offer many subscription options and flexibility to change subscriptions as and when needed\textsuperscript{xxvi}. For example subscription of e-journals for university library can be scalable as course of studies in university instead of subscription of whole e-journals package provided by suppliers or publishers.

\subsection{5.6 Pay per use}

There are no upfront costs related to purchase of a SaaS application as no licence fee is required. Client are not obligated to purchase a whole product. If customers (users)
need a piece of software for a limited period or for one purpose, they pay only for a particular time span. Subscription can be usually halted at any moment. Buyer’s risk is scaled-down to the minimum.

6. Deployment models of cloud computing:
   Four model of cloud deployment are recognized by NIST.

6.1 Private cloud
   The cloud infrastructure is operated solely for an organization. It may be managed by the organization or a third party and may exist on premise or off premise.

6.2 Community cloud
   The cloud infrastructure is shared by several organizations and supports a specific community that has shared concerns (e.g. mission, security requirements, policy and compliance considerations). It may be managed by the organizations or a third party and may exist on premise or off premise.

6.3 Public cloud
   The cloud infrastructure is made available to the general public or a large industry group and is owned by an organization selling cloud services.

6.4 Hybrid cloud
   The cloud infrastructure is a composition of two or more clouds (private, community, or public) that remain unique entities but are bound together by standardized or proprietary technology that enables data and application portability (e.g. cloud bursting for load balancing between clouds).

7. Key technologies of cloud computing
   Cloud computing is a new way of computer networking visualization. Based on centralization of data or data centre integration, it is a data-intensive super-computing. The management of cloud services, building of applications, integration of applications, multi-mode client operations and many more aspects, the cloud computing has its own unique technologies in terms of library management. A structure of cloud computing on the basis of users’ service is shown in figure 3.

In this regard, the key technologies of cloud computing are Virtualization, Web Service and Service Oriented Architecture(WSSOA), Service Flow and Workflows (SFW), and Web 2.0 and Mashup (WMp).

7.1 Virtualization
   The advantage of cloud computing is the ability to virtualized and share resources among different applications with the objective for better server utilization. For example, the figure 4 shows the virtualized ability of cloud computing over non-cloud computing.
In cloud computing, virtualization technologies include virtual machine techniques such as VMwar and Xen, and virtual networks, such as VPN. Virtual machines provide virtualized IT infrastructure on-demand, while virtual networks support users with a customized network environment to access cloud resources.

### 7.2 Web Service and Service Oriented Architecture (WSSOA)

The WSSOA are not new concepts; however, they represent the base technologies for cloud computing. Cloud services are typically designed as web services, which follow industry standards including WSDL, SOAP, and UDDI. A WSSOA also includes a set of cloud services, which are available on various distributed platforms.

### 7.3 Service Flow and Workflows (SFW)

The concept of SFW refers to an integrated view of service-based activities provided in cloud workflows have become one of the important areas of research in the field of database and information systems.

### 7.4 Web 2.0 and Mashup (WMp)

Web 2.0 is a fundamental concept that refers to the use of web technology and web design to enhance creativity, information sharing, and collaboration among users. On the other hand, Mashup is a web application that combines data from more than one source into a single integrated storage tool, therefore, the WMp technology is very beneficial for cloud computing.

### 8. Cloud computing versus cloud service

Cloud computing is the IT foundation for cloud service and it consists of technologies that enable cloud services. The key attributes of cloud computing and cloud services are shown in Table 1 and 2 respectively.

#### Table 1 (Key attributes of cloud computing)

<table>
<thead>
<tr>
<th>Attributes</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>Infrastructure systems</td>
<td>It includes servers, storage and networks that can scale as per user demand.</td>
</tr>
<tr>
<td>Application software</td>
<td>It provides web-based user interface, web services APIs, and a rich variety of configuration.</td>
</tr>
<tr>
<td>Application development and deployment software</td>
<td>It supports the development and integration of cloud application software.</td>
</tr>
<tr>
<td>System and application management software</td>
<td>It supports rapid self-service provisioning and configuration and usage monitoring.</td>
</tr>
<tr>
<td>IP networks</td>
<td>They connect end users to the cloud and the infrastructure components.</td>
</tr>
</tbody>
</table>

Source (Furht, Borko and Escalante, Armando(2010).pp8)
Table 2 (Key attributes of cloud services)

<table>
<thead>
<tr>
<th>Attributes</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>Offsite. Third-party provider</td>
<td>In the cloud execution, it is assumed that third-party providers services. There is also a possibility of in-house cloud service delivery.</td>
</tr>
<tr>
<td>Accessed via the Internet</td>
<td>Services are accessed via standard-based, universal network access. It can also include security and quality of service options.</td>
</tr>
<tr>
<td>Minimal or no IT skill required provisioning</td>
<td>There is a simplified specification of requirements. It includes self-service requesting, near dynamic and fine-grained scaling.</td>
</tr>
<tr>
<td>Pricing</td>
<td>Pricing is based on usage-based capability and it is fine-grained.</td>
</tr>
<tr>
<td>User interface</td>
<td>User interface includes browsers for a variety of devices and with rich capabilities.</td>
</tr>
<tr>
<td>System interface</td>
<td>System interfaces are based on web services APIs providing a standard framework for accessing and integrating among cloud services.</td>
</tr>
<tr>
<td>Share resources</td>
<td>Resources are shared among cloud services users; however via configuration options with the service, there is the ability to customize.</td>
</tr>
</tbody>
</table>

Source (Furht, Borko and Escalante, Armando(2010).pp8)

9. A comparative study of non-cloud and cloud computing enabled services in library management

After discussing all the above issues, we understand the numerous concepts from basic principle to advance features of cloud computing. It is also necessary to understand its utility in relation to library management in modern era of digital world. Table 3 given a comparative study between non-cloud and cloud computing based services in library management.

Table 3 (A comparative study of non-cloud and cloud computing enabled services in library management)

<table>
<thead>
<tr>
<th>Services</th>
<th>Non-cloud based services</th>
<th>Cloud computing based services</th>
</tr>
</thead>
<tbody>
<tr>
<td>Document delivery and email services</td>
<td>Set up server and a VPN for document sharing and for these purposes install necessary software including OS, web browser, and office suite</td>
<td>Use an online office application software suite (SaaS)</td>
</tr>
<tr>
<td>Library’s PCs are a year old and running desktop software slowly, but the software is old too and needs replacing</td>
<td>Upgrade computers and install new, improved desktop software including ILMS.</td>
<td>Choose SaaS and run it in a web browser on existing computer hardware</td>
</tr>
<tr>
<td>Security fears surrounding data or archived files, data stored on library server</td>
<td>Encrypt key data stored on server, so that they can't be accessed without a password.</td>
<td>Store and access data in the cloud using SaaS without backup it onto library server.</td>
</tr>
<tr>
<td>Software development required to manage OS, ILMS, web-OPAC, office suite, network tools, etc</td>
<td>Setup numerous servers for development, testing and configuration and connectivity.</td>
<td>Use a cloud based software development platform (PaaS) that supports system integration.</td>
</tr>
<tr>
<td>Automated backups for IT systems and library data</td>
<td>Setup a secondary data centre to copy backups to.</td>
<td>Use IaaS to backup data, and virtual servers.</td>
</tr>
<tr>
<td>Run a large and complex computer simulation</td>
<td>Use all available computing hardware for as long as it tasks.</td>
<td>Run the simulation on a temporary cloud based (IaaS) computer grid.</td>
</tr>
<tr>
<td>Remote working capability to enable staff to use the same desktop software and data as they have in the library</td>
<td>Set up VPN connections to allow remote desktop connections and network drive access or use a third-party service to connect to PCs in the library from anywhere.</td>
<td>User virtual hosted desktops accessible from anywhere (including library and out of university campus) or switch to other SaaS solutions.</td>
</tr>
<tr>
<td>Mobile working capability for ILMS</td>
<td>Modify key IT systems to make them accessible from mobile devices such as ‘smart' phones.</td>
<td>Use SaaS to get readymade mobile working solutions.</td>
</tr>
<tr>
<td>Need to collaborate effectively with partner libraries on-line</td>
<td>Install third-party or in-house developed software on a web server.</td>
<td>Choose and use SaaS collaboration software or develop new software with PaaS.</td>
</tr>
<tr>
<td>Initiate new service and need application software to library users</td>
<td>Create a desktop application software in-house or purchase it from third-party software developer.</td>
<td>Create web-based software through PaaS collaboration.</td>
</tr>
</tbody>
</table>

Source (Williams, Mark I(2010). pp19)

10. Challenges of cloud computing:

Cloud computing is used for enabling global access to mutual pools of resources such as services, applications, data servers, and computer network. It is done on either a third-party server located in a data centre or a privately own cloud. This makes data accessing contrivances more reliable and efficient, with nominal administration efforts. However, with numerous advantages, there are some challenges also concerned in cloud computing and if we have not prepared to deal with them, we would not realize the benefits. Here are some challenges have been discussed and it should be considered before put into practice of cloud computing in a library.

10.1 Cost

Cloud computing itself is affordable but tuning the platform according to the institution’s need can be expensive, especially bandwidth cost.
10.2 Service provider reliability

The capacity and capability of a technical service provider are as important as price. The service provider must be available when we need them. The main concern should be the service provider’s sustainability and reputationxxxii.

10.3 Continues monitoring and supervision

Cloud computing often suffers from frequent outages, owing to the lack of round-the-clock service on the part of cloud providers. It is important to monitor the cloud service continuously as well as to supervise its performancexxxiii.

10.4 Security concerns

Addressing the security concerns of any data on cloud platform is a major challenge. This obviously concerns the enterprises, as hacking or other attacks on the cloud infrastructure could damage or expose the data of multiple clients. To prevent such damages, some of the measures including tracking unusual behavior across subscribers, buying security hardware and using security applicationsxl.

10.5 Password security

Industrious password supervision plays a vital role in cloud security. Anybody aware of super-user/database access password will be able to access the data and document such as subscribed e-books, licence e-consortia, subscribed e-journals and online database, etc. through cloud computing from library’s cross-linked platform. For technical measures related to unauthorized access, make sure that passwords are protected and altered regularly and access rights should only be allocated to those who require themxl.

11. Conclusion

The present analysis of topic is apparent that the cloud computing can be implemented in a composite form through a well-defined method in library. In recent year, the community power is gradually raised in terms of data access and their usefulness, regarding these; libraries have to some extent unique opportunity with cloud computing, to create an online information community network. Electronic resources in worldwide now potentially impact the library management including financial aspects and potential for collaboration between libraries is really a progressive step in a cloud environment, where e-resources are shared in the cloud libraries can make joint collaboration on collection development, documents digitization as well as documents preservation in on-line mode.

References

5. Ibid. 9
6. Ibid. 9
9. Ibid.


Ibid. pp17

Ibid. pp17

Ibid. pp17


Ibid. pp10

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Ibid.[Access on 26-12-2018]

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