

# Cloud Computing and its Application in Libraries

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**Abstract:** Cloud Computing is the stepping stone to Lancaster’s forecasted ‘Paperless Society’. The paper defines Cloud computing and sum up Cloud computing architecture, its key characteristics and four types of deployment models and three types of service models such as IAAS, SAAS and PAAS. Recapitulate important Cloud computing initiatives for libraries such as OCLC WorldShare Management Services (WMS), Ex Libris, Polaris Integrated Library System, Dura Cloud, LibLime, The 3M Cloud Library App. Briefs applications of cloud technologies in libraries including “dark archive solution” CLOCKSS and PORTICO, and advantages and disadvantages of Cloud computing. Cloud computing allows the library to provide IT infrastructure on a subscription model that may be difficult to acquire and manage otherwise, to employ a pay-on-demand resource model, and to scale its technology resources. With cloud computing, library services can have a new leap in future and it will become more effective, user-centric, sophisticated and more professional. It can help to move towards IT World and Library Greener.

**Keywords:** Cloud computing, Cloud Architecture, Software as a Service, Platform as a Service, Infrastructure as a Service, CLOCKSS, PORTICO.

## 1. INTRODUCTION

Cloud computing, one of the most exciting developments has become omnipresent among the technocrats and enthusiastic librarians world over as a technology solution as well as resource sharing venture. It is sometimes compared with the virtualization of computing power, applications and storage, thought of as a model to deploy pay-as-you-go web services or perceived to be similar to grid computing and shares characteristics with all of these technology paradigms and more. Cloud computing, the new technology model is the use of computer resources (hardware and software) that are delivered as a service over a network. It is named after the use of cloud - shaped symbol it contains in system diagrams as an abstraction for the complex infrastructure. Cloud computing has been coined as an umbrella term to describe a category of sophisticated on-demand computing services initially offered by commercial providers such as Amazon, Google, and Microsoft. It denotes a model on which a computing infrastructure is viewed as a “cloud,” from which businesses and individuals access applications from anywhere in the world on demand<sup>1</sup>. The main principle behind this model is offering computing, storage, and software “as a service.”

## 2. CLOUD COMPUTING-DEFINITION

Cloud computing is a revolutionary universally available system which makes utility computing possible with pay as you go and infinity scalable, though the technology it is built upon is evolutionary. According to Sosinsky “Cloud computing takes the technology, services and applications that are similar to those on the Internet and runs them into a self-service utility. The use of the word “cloud” makes reference to the two essential concepts:

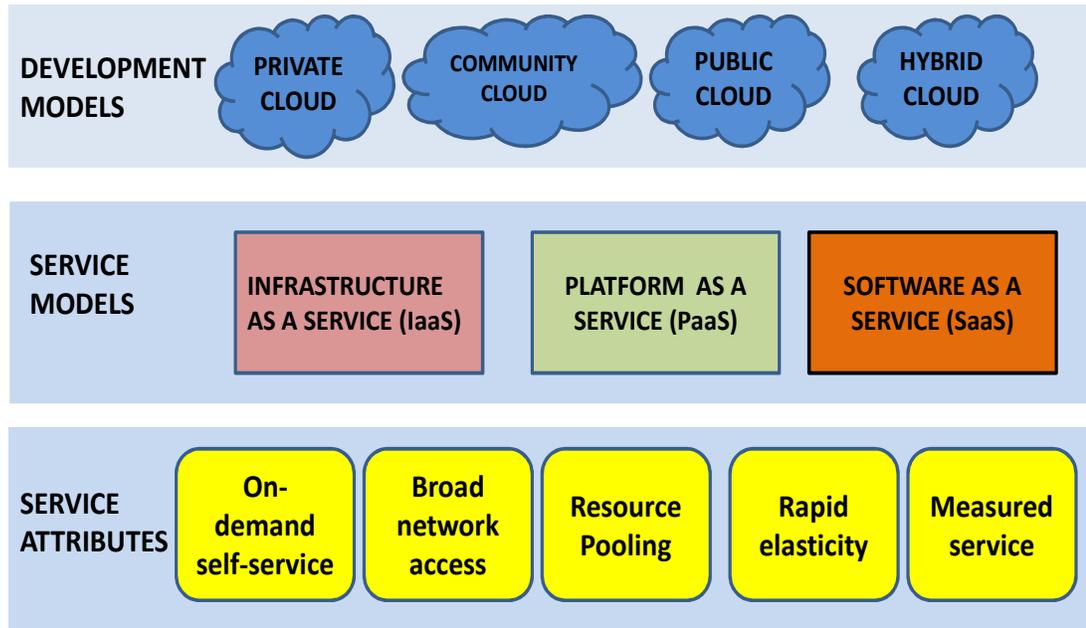
- Abstraction: Cloud computing abstracts the details of system implementation from users and developers. Application run on physical systems that are not specified, data is stored in locations that are unknown, administration of systems is outsourced to others, and access by users is ubiquitous.
- Virtualization: Cloud computing virtualizes systems by pooling and sharing resources. Systems and storage can be provisioned as needed from a centralized infrastructure. Cost are assessed on a metered basis, multi-tenancy is enabled and resources are scalable with agility”<sup>2</sup>.

Gartner IT Glossary defines cloud computing as a style of computing in which scalable and elastic IT-enabled capabilities are delivered as a service using Internet technologies<sup>3</sup>.

Buyya et al. have defined it as follows: “A Cloud is a type of parallel and distributed system consisting of a collection of inter-connected and virtualised computers that are dynamically provisioned and presented as one or more unified computing resources based on service-level agreements established through negotiation between the service provider and consumers.”<sup>4</sup>

According to NIST “Cloud computing is a model for enabling ubiquitous, convenient, on-demand network access to a shared pool of configurable computing resources (e.g., networks, servers, storage, applications, and services) that can be rapidly provisioned and released with minimal management effort or service provider interaction. This cloud model is composed of five essential characteristics, three service models, and four deployment models<sup>5</sup>”.

## The NIST Cloud Computing Definitions



### 3. CLOUD COMPUTING ARCHITECTURE

Cloud computing architecture can be divided into two sections; the front end and the back end. They connect to each other through a network, usually the Internet. The front end is the part seen by the computer user or client. It consists of the client end hardware and software that helps to access the cloud network via a user interface such as a browser. Front end client software usually work as independent application. Back end, the 'not-seen' end of the network is essentially the group of machines that form the cloud. Back end of the cloud computing framework is made by hardware-like servers, processors etc and an array of software that provides the crux of the cloud service. A central server does bulk of administration work and take care of the traffic monitoring and resource allocation to satisfy the client demands and to ensure everything runs smoothly. It follows a set of rules called protocols and uses a special kind of software called middleware. Middleware allows networked computers to communicate with each other. Most of the time servers do not run at full capacity which leads to wastage of unused processing power. There is a hi-fi-term called server virtualization where in a physical server is divided into a number of virtual servers each running at maximum capacity. This technique reduces the need for more physical servers in the cloud computing framework. A user can access

the cloud using a service on his mobile device, PC, tablet etc.<sup>6</sup> Customization and creation of a user-defined experience is the key element of Cloud Computing.<sup>7</sup>

#### 4. ESSENTIAL CHARACTERISTICS

National Institute of Standards and Technology's definition of Cloud Computing recognize five essential characteristics as follows<sup>8</sup>

- On-demand self-service
- Broad network access
- Resource pooling
- Rapid elasticity
- Measured service

#### 5. CLOUD MODELS

Cloud computing entrust remote services with the user's data, software and computation. It is separated into two distinct sets of models according to widely accepted NIST demarcation:

**5.1 Deployment models** (four types):- Private, Community, Public and Hybrid, the four types of deployment models refers to location and management of cloud's infrastructure

**5.2 Service models** (three types): – SAAS, PAAS and IAAS the three different service models taken together are known as SPI Models of cloud computing. These consist of the particular types of services that can be accessed on a cloud computing platform.

##### 5.1 Deployment Models

**5.1.1 Private cloud.** The cloud infrastructure is operated for exclusive use by a single organization comprising multiple consumers. It may be present either on or off premises and owned, managed, and operated by the organization, or a third party, or some combination of them.

**5.1.2 Community cloud.** Community clouds are stipulated for exclusive use by a particular community of consumers from organizations that have shared concerns.

**5.1.3 Public cloud.** An academic, government, or business organization, or a combination of them can own and operate a Public cloud. It exists on the premises of the cloud provider and is opened for the use of general public.

**5.1.4 Hybrid cloud.** A hybrid cloud is a combination of public, community or private cloud. It is also known as combined cloud. In hybrid cloud, private and public clouds retain their unique identities but are bound together by standardized or proprietary technology that enables data and application portability. An example of hybrid cloud is Google Apps.

##### 5.2 Service Models:

###### 5.2.1 Software as a Service (SaaS)

Software as a Service (SaaS) makes use of a cloud computing infrastructure to deliver one application to many users, regardless of their location, rather than the traditional model of one application per desktop. It allows activities to be managed from central locations in a one-to-many model, including architecture, pricing, partnering, and management characteristics.<sup>9</sup> Some of the examples of SaaS cloud service providers are Google Apps, Salesforce.com, SQL Azure, Twitter, Microsoft 365 and Oracle On Demand. Unauthorized access to data is a drawback of SaaS as user's data is stored on the Cloud provider's server.

###### 5.2.2 Platform as a Service (PaaS).

PaaS provides virtual machines, operating systems, applications, services, development frame works transactions and control structures. The client can deploy its applications on the cloud infrastructure or use applications that were programmed using languages and tools that are supported by the PaaS service provider. While client is responsible for installing and managing the application that it is deploying; the service provider manages the cloud infrastructure, the operating systems and the enabling software<sup>10</sup>.

PaaS saves costs by reducing upfront software licensing and infrastructure costs, and by reducing ongoing operational cost for development, test and hosting environment. An example of PaaS service is that Salesforce.com opened an API called the Force API that allowed developers to create applications based on the Salesforce.com technologies. Other important examples of PaaS are Google App Engine, Windows Azure cloud services, Openshift, Force.com.

### **5.2.3 Infrastructure as a Service (IaaS).**

Offering virtualized resources (computation, storage, and communication) on demand is known as Infrastructure as a Service (IaaS)<sup>11</sup>. Examples of some IaaS service provider are Amazon elastic compute cloud (EC2), GoGrid, FlexiScale, Linode, RackSpace, Verizon Terremark, NaviSite, Google Compute Engine and HP cloud.

There are many service models described in literature such as Network as a Service (NaaS), Storage as a Service (SaaS), Backup as a Service (BaaS) etc. All of the models take the form as XaaS or “<something> as a service” Anyway SPI services cover all the other possibilities i.e. Everything as a Service (EaaS). Companies such as Google, HP and Microsoft have frequently been associated with the EaaS concept<sup>12</sup>.

## **6. CLOUD COMPUTING – A LEAD TO ‘PAPERLESS SOCIETY’**

Cloud Computing is the stepping stone to Lancaster’s forecasted ‘Paperless Society’. Knowingly or unknowingly we are engaged in cloud computing while connected to the Internet services like Google’s Gmail, Facebook and Flickr. Organizations would be required to purchase / upgrade the whole bunch of computers as the software go out dated and the old computers may not have the necessary space to run the new version of software. At least in theory this problem is solved in cloud computing, as the software and hardware required to run it are on somebody else’s server. What you need to do is to install an application that serves as the interface to the service. The computer needs only enough resources to run and display the interface using a web browser as the connected server does all the processing and saves your data. E-mail services are cloud based as the whole sending and receiving are carried out by a server and your mails are stored off shore.

Cloud computing allows the library to provide IT infrastructure on a subscription model that may be difficult to acquire and manage otherwise, to employ a pay-on-demand resource model and to scale its technology resources. Cloud libraries are becoming very popular in US and other Western Countries. They use cloud architecture in which internet based ‘on demand service’ is provided. They provide flexible e-book/document lending service through in-library hardware. Catalogue searching facility in the library is provided through the touch-based terminals and books selected will be checked out to users along with e-readers. Users can borrow digital books in their mobile devices, iPads and android based tablets.

## **7. CLOUD COMPUTING INITIATIVES FOR LIBRARIES**

### **7.1 OCLC WorldShare Management Services (WMS)**

WorldShare Management Services (WMS)<sup>13</sup> an integrated suite of cloud-based library management applications of OCLC offer libraries cost savings, workflow efficiencies and the

ability to deliver new value to users by sharing data and work across many member libraries. Traditional ILS systems often require costs to maintain servers and software and these costs are eliminated with WMS. WMS subscription includes serials management, course reserves, openURL resolver, A- Z list services, and WorldCat Discovery Services with available options for group views, remote database search and custom reporting. WMS integrates all electronic and print resource management workflows including selection, acquisitions and maintenance within the same Web-based WorldShare interface. WorldCat Discovery provides your library more visibility on the Web and better information about your systems. A report authoring tool which provides user-specified, peer comparisons based on OCLC cooperative data is also available at an additional cost.

## **7.2 Ex Libris**

Ex Libris Group<sup>14</sup> is a leading provider of library automation solutions, offering comprehensive product suite for the discovery, management and distribution of all materials-print, electronic, and digital. Ex Libris caters to libraries of all type and size and to large consortia. It is built on open architecture and are flexible, customizable, easy to maintain and manage, and Unicode-compliant, with full multilingual capabilities. It can be implemented as stand-alone solutions or integrated with existing environments.

Ex Libris has developed the Alma, the cloud-based library resource management system to consolidate, optimize and extend the range of library services. It consolidates and extends library's operations with a unified, SaaS platform for electronic, print and digital resources. It supports the entire suite of library operations -selection, acquisition, metadata management, digitization, and fulfillment-for the full spectrum of library materials, regardless of format or location. They claim that using web-based, open interfaces, it can be integrated effortlessly with other systems including external campus systems, and libraries can develop adapters and plug-ins to meet their institutions' unique needs. Kingston University in London is using the Ex Libris Alma, the cloud-based resource management system to transform the management of its electronic and print resources and multi-site collections<sup>15</sup>.

## **7.3 Polaris Integrated Library System**

The Polaris ILS provides a robust and scalable software solution with powerful staff tools and an intuitive experience for patrons. The Polaris ILS built on a Microsoft SQL server database platform with documented APIs is open to connections with third-party vendors, with patrons and their social media, and with resources beyond the walls. Its integrated expanded functionality enables direct access to e-content, shared collections, and outside systems. One can integrate the system with seamless patron access to resources by utilizing INN-Reach or a consortium network; direct patron access to 3MCloud Library, OverDrive, and Axis 360 eContent; and APIs that power direct connections to outside systems. The Polaris ILS offers a fully-documented Microsoft SQL database schema, facilitating construction of powerful searches and reports. Tools such as search alerts, fine estimators, and reading history, patrons can easily manage their accounts and maintain their connection with your library<sup>16</sup>.

Polaris ILS 5.0 includes several new features such as Family Holds Pickup, floating collections by collection with optional load balancing, the ability to automatically renew items, a Carousel Toolkit, the ability to automatically close purchase orders, and the ability to automatically flip bibliographic display in the PAC.

Polaris Leap is the new web client for Polaris ILS that performs public services workflows, such as registering new patrons and checking out items and works on devices such as tablets and laptops, enabling library staff to serve their patrons even outside library walls. Both

Polaris Leap and Polaris ILS 5.0 will be officially launched into general release in October 2014.<sup>17</sup>

#### **7.4 Dura Cloud**

DuraCloud is an open source platform developed by DuraSpace which was released broadly as a service in 2011. It provides on-demand storage and services for digital content in the cloud for academic libraries, academic research centers, and other cultural heritage organizations. DuraCloud enables digital preservation, data access, transformation and data sharing. It helps to move copies of content of any shape or size into the cloud and store them with several different providers and offers compute services. The DuraCloud easy-to-use dashboard allow scholars to easily upload and download content and permits to add tags and metadata to content through their interface. DuraCloud is also integrated with the DSpace and Fedora repository platforms and offer "elastic capacity" coupled with a "pay as you go" approach<sup>18</sup>.

#### **7.5 LibLime**

LibLime, founded in 2005, owned by Progressive Technology Federal Systems, Inc. (PTFS) from 2010, is a commercial entity providing implementation and development services around the open source Integrated library system Koha, which is generally considered to be the earliest. It is one of the most innovative technology platforms which bring new realities of open access, interoperability, rapid and flexible development. It is used by all types of libraries and consortia with confidence as it couples the concept of open source with the security of outstanding customer service and relieves libraries from the need to have expensive technical resources on staff. Hosted in LibLime's distributed cloud computing data center, hundreds of libraries are able to alleviate their internal IT support needs. LibLime Koha distributed via Software as a Service (SaaS) backed by professional support team is completely web-based and built on MySQL; all data and list-serv are readily accessible to all users via a web browser and pricing is based on bibliographic record count<sup>19</sup>.

#### **7.6 The 3M Cloud Library Application**

The 3M Cloud Library application is an innovative way to browse borrow and read popular fiction and non-fiction eBooks from local public library. Patron should have a valid library card to use the 3M Cloud Library App and the library needs to have a subscription to the 3M Cloud Library service. Users can use the 3M Cloud Library PC Software to transfer eBooks to their Nook Simple Touch, Kobo eReader, or Sony eReader. One can take notes while reading or can create their own bookmark. The 3M Cloud Library automatically syncs to all your devices that have the 3M Cloud Library App downloaded to them. User can start reading on his iPad and even continue reading from his phone right where he has left off<sup>20</sup>. The application has the ability to transfer content to a personal e-reader using either an existing Adobe ID or using the 3M Cloud Library ID. The 3M Cloud Library is not currently supported by Amazon.

The new 3M Cloud Library app features a completely redesigned interface with numerous options for patron personalization, allowing users to browse and check-out titles more easily than ever before. Along with an improved app experience, patrons continue to enjoy 3M Cloud Library's expanded content with the addition of eight new publishing partners, bringing the platform's total titles to more than 300,000 high-quality offerings<sup>21</sup>.

### **8. APPLICATIONS OF CLOUD TECHNOLOGIES IN LIBRARIES**

Libraries have been using the cloud computing services such as online databases and large union catalogues for over a decade. While planning to use third party services one need to

have thorough idea about the whole system and should search and find out the standard company who has experience in handling such services. There are many cloud service providers such as Ex Libris, Duracloud and Polaris Library System in the market which can provide these types of services. Cloud computing can manage many common challenges of library such as scarce resources, increased user demand, ever more complex collections, systems and workflows to a great extent. Cloud-based library management services are offering workflows that save time and discovery solutions that meet users' expectations because of the integration in the cloud between libraries, applications, partners and data. Libraries are experimenting with all types of cloud computing services including that of infrastructure services, i.e. IaaS. Libraries can utilize cloud computing services such as SaaS, PaaS, and IaaS in a number of areas such as library automation, website hosting, digital library services, search services, Storage, Integrated Library System (ILS), Inter Library Loan system etc.

### **8.1 Automation**

At present automation in most of the libraries are carried out on local servers by using different types of commercial or open source integrated library management software and managed by internal IT / library staff. Now many software vendors (e.g. Ex-Libris) offer this on the cloud (SaaS model) which enables the library free from investing on hardware and undertaking maintenance, software updating and backup.

### **8.2 Website hosting**

Libraries can host their own websites with the help of cloud technologies. Most of the libraries prefer to host their websites with third party service providers rather than hosting and maintaining their own servers due to dearth of required technical manpower to maintain the servers. Google Sites serves for hosting library websites. The District of Columbia Public Library is using Amazon's EC2 service to host their website and provides rapid scalability and redundancy to libraries<sup>22</sup>.

### **8.3 Search Services**

Using commercial or open source solutions libraries have already migrated key services such as OpenURL providers, and federated and pre-indexed search engines on the cloud. For example, hosted Ex-Libris SFX Open-URL link resolver service offers libraries to linkup to the subscribed journal full-text articles. Ex Libris' SFX, use OpenURL to provide library patrons with context-sensitive links, such as the ability to move quickly from a citation in an abstracting and indexing database to the full text. In SFX, information for determining the appropriate links is maintained in the knowledge base, which contains details about a library's electronic holdings and other information about electronic information resources.<sup>23</sup>

### **8.4 Storage**

At present, Libraries store and access the electronic documents, bibliographic records, tutorials etc. using personal desktops or servers which are locally hosted. The cloud computing has brought new services, which even offer space at no cost to store the files and documents. For example, cloud storage services such as Dropbox<sup>24</sup>, Google Drive<sup>25</sup>, Microsoft OneDrive<sup>26</sup>, Box<sup>27</sup>, Apple iCloud<sup>28</sup>, Spideroak<sup>29</sup>, Amazon Cloud Drive<sup>30</sup> and other initiatives offer storage space on the cloud to enable organizations and individuals to store and share their documents, sync across multiple devices, and enable to work collaboratively on the web irrespective of their geographical location. While Microsoft OneDrive and Google Drive offer 15 GB each, Box offer 10 GB, Apple iCloud and Amazon Cloud Drive offer 5 GB each and Dropbox and Spideroak offer 2 GB each free space to store and share documents, photos and videos online. Libraries may take advantage of this offer in order to undertake collaborative activities with other libraries.

CLOCKSS<sup>31</sup> (Controlled Lots of Copies Keeps Stuff Safe) and PORTICO<sup>32</sup> offers libraries a permanent "dark archive solution" of e-journals, e-books, and digital collections, providing protection against the potential loss of access to e-literature integral to a library's collection. In India National Centre for Biological Sciences and Tata Institute of Fundamental Research Bangalore are using Portico.

### **8.5 Digital Library Services**

Presently, the digital library services are being offered by libraries mostly using locally hosted open source software such as DSpace, Greenstone, EPrints, Fedora Commons etc for providing open access to scholarly resources. Now vendors such as Duraspace offer digital library services on the cloud using SaaS approach which relieves libraries from maintaining separate servers and tedious work of taking backups and updating of new versions of software.

## **9. ADVANTAGES AND DISADVANTAGES**

Cloud computing like any other technology; also have its strength and weaknesses, which needs to be taken into consideration before implementing this new technology.

### **9.1 Advantages**

1. Cost effective: The Cost is reduced in terms of manpower, material, running costs.
2. Reduces storage space: You are no longer restricted by your computer's limited storage space. You can simply save your data in the cloud and log in to view and edit it as needed.
3. Reduces hardware and maintenance cost: There is no need for the user to invest in high end software and hardware or be tied to constant upgrade cycles as cloud based services utilize hardware and software on the cloud. Usually only system capable of running a web browser is required at the user end.
4. More computing power: Computing is done on cloud, and hence large scale computations can be managed by better machines.
5. Round the clock access from any where:  
Major benefit of Cloud application is around the clock availability; all you need is an Internet connection with right authentication details and you can access whenever without any geographical location i.e. remotely from home, or on the move. Cloud Services also allow you to synchronize data across multiple devices.
6. Infinitely scalable  
Users can access the resources they need in line with their changing requirements. Usage-based pricing models ensure that they only pay for the services actually used by them and this cost transparency gives a reliable basis for planning.
7. Automatic and secure data backup  
Estimate suggests that about 80,0000 laptops are lost every year at airports alone. Data backup ensures that you do not lose just more than your laptop.<sup>33</sup> Further no need of worries about mislaid USB sticks or the inconvenience associated with sending and opening email attachments. You are no longer restricted by your computer's limited storage space: simply save your data in the cloud and log in to view and edit it as needed.
8. Increased collaboration, faster provisioning of systems and applications  
Cloud solutions also allow exchanging enormous data and documents more easily and efficiently than ever before. Because of easier action employees can share information and work on documents and shared applications simultaneously. Eg. Google apps and Zimbra.

### **9.2 Disadvantages of cloud based services<sup>34</sup>**

1. Need for Constant connectivity

One of the major drawbacks of every cloud service is the need for constant connectivity with Internet. Varying bandwidth at the end might cause errors to creep in and this limits the use of cloud services.

## 2. Complexity

While cloud services enhance and ease library performance they are initially complex to understand. Hence employees and users have to be trained for better utilization of cloud based services.

## 3. Latency

Latency, an obvious issue is the time taken for the user system to interact with machines in the cloud. Cloud based apps will have higher latency than the native apps installed on a users system since there will be an added time of user end communicating with the cloud. Further, higher traffic and un-favourable geographical location can aggravate the problem.

## 4. Security

Cloud computing is completely Internet based and all cloud based computing uses and stores data using the same network which makes it vulnerable to attack by hackers. Porting to the cloud can actually be more secure for smaller companies as companies offering cloud services use the latest and most sophisticated security methods.

## 5. Privacy

Privacy loss is a big concern when we talk about cloud-based services. Data stored or shared on the cloud by large social networking sites are usually protected and can be accessed by only authorized people, but there is always a chance of accidental data leakage, mismatch and other failures.

## 10. Conclusion

Libraries have to integrate and manage electronic, digital, and print resources; optimize workflows through shared data and collaborative services; and extend the range of library services to support rural masses regardless of location; as well as transmit resources within and outside their institutions in direct support of teaching, learning, and research goals of the nation. It is important to see that the library is capable of managing different resource formats with scalability to handle growing volumes of digital media. Cloud computing is a legitimate concern with all controversy over privacy of data in this digital age. Librarians, especially that of special and academic libraries cannot refrain from this revolution any more, and should take it as a challenge. On utilizing cloud computing to deliver library resources, services and expertise to users to their fullest satisfaction at their pace, libraries can be liberated from managing technology and can focus on collection building and other innovative services. With cloud computing, library services will have a new leap in future; and it will become more effective, user-centric, sophisticated and more professional. More over as less carbon emission is expected in Cloud computing due to sharing of computing power; it can help us to move towards IT World and Library Greener.

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