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Inherent Conceptions of Cloud Computing among Library and Information Science professionals

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Abstract

The present study is an attempt towards identification, systematization and critical examination of the research literature on the concepts of cloud computing prevalent among the Library and Information professionals. The study is based on an exhaustive review of the published literature in the field of cloud computing and library and information science. For the review, a conceptual framework was developed in order to demarcate the flow of available information. Available strategies, models, frameworks and existing practises of adoption of cloud computing in library practises have been exclusively dealt. Based on the review the study proposes several gaps in the existing literature which needs to be worked out in the future researches. The study will provide a theoretical background for the study of cloud computing with a slant to library and information science discipline.

Keyterms: Cloud Computing, Library & Information Science, Emerald, Science Direct, LISTA, DOAJ.

Introduction

Libraries continue to be not only early adopters of new technologies, but also early users of cutting-edge technologies they see as being effective to their mission of providing information for all. In recent years, cloud computing has clearly proven to be a lasting technological innovation that will continue its rise in usage and not just a fad that will fade away or be replaced by the next innovation. The present paper is an attempt to explore the concepts prevalent among the librarians and in the existing literature on cloud computing and its association with the libraries.

Objectives

The study was carried out with following objectives:

1) To examine the concepts of cloud computing among library professionals.
2) To determine the scope of cloud computing in LIS profession.
3) To examine the opportunities and threats for LIS professionals as emerged from the origin of cloud computing platforms.
4) To identify the requirement of competencies among LIS professionals for their involvement in cloud computing environment.

Methodology

As the present study was targeted towards the analysis of the concepts of cloud computing among LIS professionals, literature survey method was found suitable. 65 articles related to cloud computing and librarianship were identified from various databases, including Web of Science, Emerald, Science Direct, Library, Information Science and Technology Abstract (LISTA), Directory of Open Access Journals (DOAJ), Google Scholar and J-Stor, using the combination of keywords cloud computing and libraries. As the study only included the results obtained through the keywords, the literature review was narrow to a great extent.

For convenience of interpretation and discussion the review study has been based on a conceptual framework that has been divided into various sections. The conceptual map that follows (Figure 1) was designed as an attempt to link the diversifying concepts that appears in the related literature. The intention was to map the current research in the topic and discover the potential research gaps which need to be worked out. Implementation of cloud computing in the academic libraries is a relatively new phenomenon where the research is at nascent stage the conceptual framework may not be complete but rather a work in progress. New topics can be added as branches in the conceptual map.

Extracting the idea that underlie within the available literature of cloud computing the conceptual framework approaches the steps of cloud adoption in the academic libraries. Henceforth, the associated benefits, challenges of cloud computing in libraries, case studies, focus on the library services in the cloud have been considered as the first stage of cloud adoption that examines the suitability of cloud computing in libraries. Specialized frameworks, Use cases and SWOT analysis has been considered as the part of migration strategy library services to the cloud. The proposed security measures and standards are part of the cloud architecture for academic libraries. The arrows appearing as link of different groups are indicative of the dependency relationship among them.

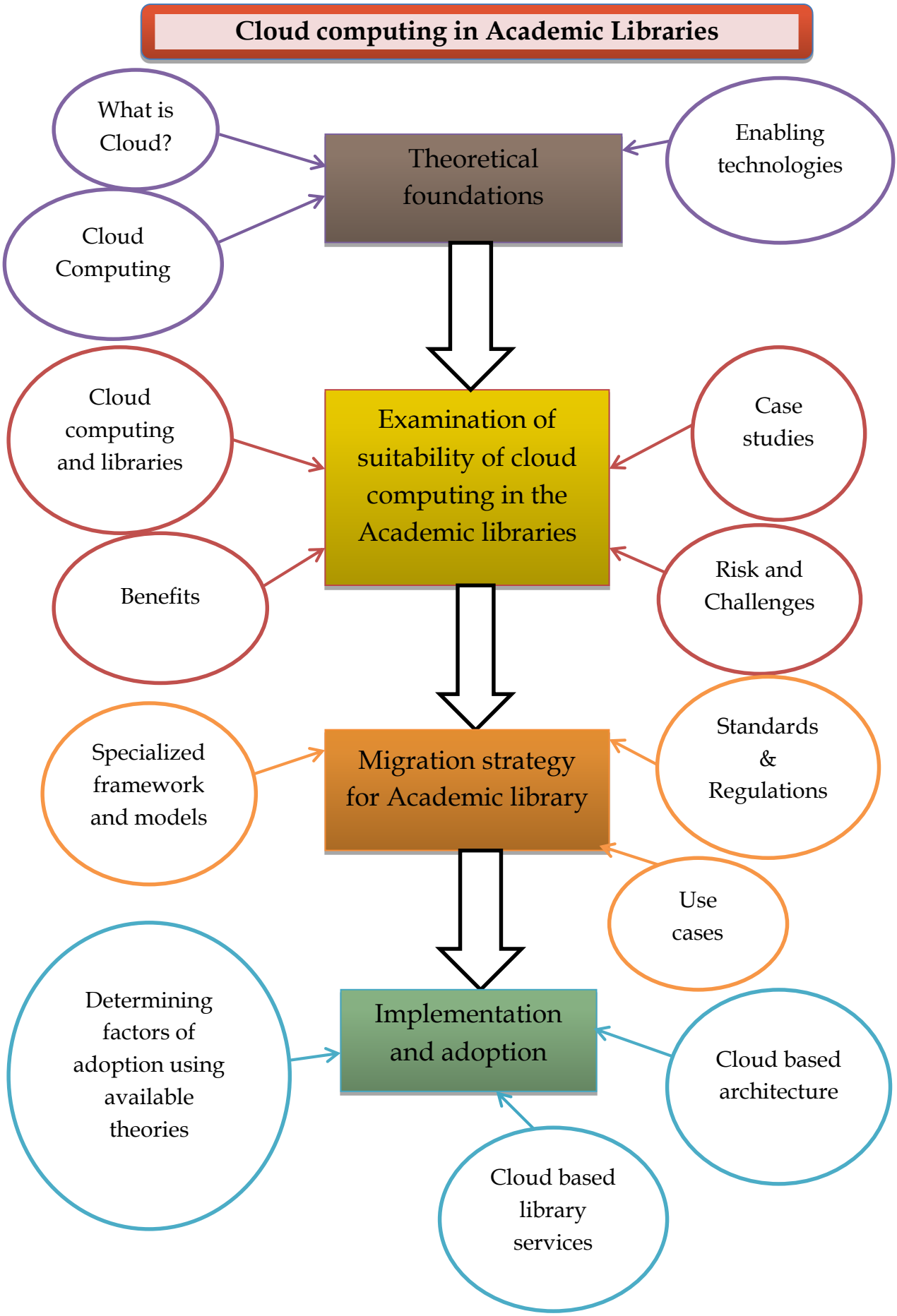
Cloud computing in Academic Libraries
What is Cloud?
Cloud Computing
Theoretical foundations
Enabling technologies
Cloud computing and libraries
Benefits
Examination of suitability of cloud computing in the Academic libraries
Case studies
Risk and Challenges
Specialized framework and models
Migration strategy for Academic library
Standards & Regulations
Use cases
Determining factors of adoption using available theories
Implementation and adoption
Cloud based architecture
Cloud based library services

Fig 1: Conceptual framework of cloud computing literature survey

The paper is organized into five sections. The first section is devoted to the concept of cloud computing. The second describes the concepts of cloud computing and its relationship with librarianship and information science. The third examines the scope of cloud computing in the LIS profession. The fourth discusses the opportunities and threats emerged from the origin of cloud computing environment. In the final section, a discussion on the requirements of competencies for LIS professionals in order to work in a cloud computing environment is presented.

Concept of "*Cloud*" in cloud computing

The usage of the word "cloud" has been mystery for the scholars. In order to understand cloud computing it is essential to understand the concept of cloud. Defining the cloud element of cloud computing and tracing its roots has witnessed divulging viewpoints. However, all the propositions more or less account a single ideology.

Some scholars trace the origin of the term "cloud" to the concealing nature of this technology's framework where the system works for users yet they really have no idea about the inherent complexities that the system utilizes. What they do not realize is that there is a massive amount of data being pushed globally in real time to make these applications work for them, the scale of which is simply amazing (Blokdijk and Menken, 2009).

Meanwhile studies also point out towards the vagueness of the term that has been used symbolic to represent the infrastructure of cloud computing. From IT Infrastructure side (Reese, 2010) views cloud as an electronic village that has got thousands of thousands server farms, network equipment for providing communication between server farms, controller mechanisms for management, storage area networks (SANs), Firewalls and other security devices. In fact, the cloud symbol was used in network diagrams to denote the margin point between the responsibility of the provider and user which was extended to include servers and the network infrastructure in the cloud. For example, Tadwalker (2009) states that cloud computing derive its name from cloud which represents data centres, technologies, infrastructure and services delivered through internet. Similar thoughts have been put forth by (Kennedy, 2009) who argues that the term cloud is used to include things like virtual servers which is difficult to locate as users are completely unaware that where their data is being stored or managed. According to (Powell, 2009) the cloud can be viewed as an infrastructure for on-demand computing, for anyone with a network connection.

Complementing to the studies (Armbrust et. al., 2009) argue that "clouds can be defined as computers that are networked anywhere in the world with the availability of paying for the used clouds in a pay-per-use way, meaning that just the resources that are being used will be paid for". Similarly, (Convery and Ferguson-Boucher, 2011) point out that cloud as such is composed of hardware, storage, networks, interfaces and services that provide the means through which infrastructure, computing power, applications and services are accessed by the user on demand and independent of location. According to PC Magazine's Tech Encyclopedia (n.d.) clouds generally refer to wide area networks (WANs) such as the Internet, but can also be used to depict local networks (LANs).(Singh and Channa, 2013; Lasica, 2009) claim that the name comes from the use of a Cloud-shaped symbol as an abstraction for the complex infrastructure (virtual servers, distributed hosting and shared resources available over the Internet) it contains in system diagrams. According to (Reese, 2010) the cloud contains both IT physical infrastructure and software which can be software a user accesses via the web or a physical server which can be used exactly when it is required. Further, (Velte, 2010) put forth the view that for Cloud Computing world, the cloud means that it is all that other stuff that makes the network and system work which is a kind of like ―etc. for the rest of the IT solution maps from client.
Another group of studies claim that cloud computing in essence is internet based computing and since internet was represented in network diagrams through a clod icon in their notations, it got the name. For

example, (Molen, 2010) puts forth the view that the term "Cloud" originated in the telecommunications world where telecommunications networks and the Internet were visualized on technology diagrams as Clouds, signifying areas where information was moving and being processed, without the average person needing to know exactly how that happens". A report released by Union des consommateurs in 2011 claims that the cloud in question is actually the symbolic representation of the Internet and is used by engineers when they talk about the Internet while the term "computing" refers to functionalities offered by computers, i.e., calculation or data storage capacities. As a joint term, cloud computing purportedly offers users the possibility of using the Internet as a place where computer calculation or data storage is made available to the public. Further, (Rittinghouse and Ransome, 2010) opines that the term Cloud has been used historically as a metaphor for the Internet. This usage was originally derived from its common depiction in network diagrams as an outline of a Cloud, used to represent the transport of data across carrier backbones (which owned the Cloud) to an endpoint location on the other side of the Cloud.

Commenting on the term cloud (Lasica, 2009) is of the view that the shift towards cloud services and the cloud as a platform is an evolutionary one, which denotes a process in which the cloud itself disappears into the background as it becomes just an unspoken part of the way things are delivered through the internet. According to KPMG group (2011) cloud can be viewed as summation of internet based data access and exchange process and internet based access to low cost computing and applications. Alternatively, the "cloud" element of cloud computing can be seen as an acronym that stands for C- Computing resources, L- that is Location independent, O- can be accessed via Online means, U- used as an Utility and D- is available on Demand (Yuvaraj, 2014).While, (Mei, Chan and Tse, 2008) put forth the view that the prime focus of cloud computing is on data sharing and computations over a scalable network of nodes such as end user computers, data centres and web services and these network of nodes are referred as a cloud. On the other hand, (James, 2010) argues that "Viewing the cloud narrowly in cost and risk is to miss the social impact of the technology. No technology is perfect but appropriately positioned technology becomes viral in adoption. The cloud in fact is the content bazaar of the Web".

Cloud Computing: Intellectual contestations

Cloud computing has emerged as a forefront research channel that has enormous storm within itself that can change the face of IT industry. The importance of cloud computing as a technology of future has drawn attention from a diverse group of researchers. Many scholars have attempted to study cloud computing from different perspectives targeted to serve different purposes. Moreover, it has been discovered there are several whitepapers and general introductions to cloud computing that provide an overview to the field (Sun Microsystems, 2009; Fellows, 2008; Varia, 2009; Chappell, 2009; Rayport, 2009; IBM 2009, Gartner 2008, Forrester Research, 2008) but it has been largely undefined due to the different aspects of the definers. Due to the lack of a universal definition and various perceptions of Cloud Computing, including the related benefits and challenges, many companies struggle to make use of the Cloud concept (Nuseibeh, 2011; Leavitt, 2009; Marston et al. 2011). A report released by Union des consommateurs in 2011 reveals that unsurprisingly, the definition of cloud computing has been amply discussed on cloud in social networks and Internet users' blogs. (Mell 2011 & Vaquero 2009) after reviewing the many possible definitions on cloud computing argues that most of them focus on the technology only. Vaquero (2009) gave a serious note to the definitions of cloud computing available in the literature and tried to combine the different definitions in order to come up with one (proposed) uniform definition. McKinsey & Company (the global management consulting firm) after reviewing 22 research articles has put forth a new definition (Forrest, 2009) which states that cloud computing is hardware-based services offering compute, network and storage capacity where:

1. Hardware management is highly abstracted from the buyer;

2. Buyers incur infrastructure costs as variable OPEX;

3. Infrastructure capacity is highly elastic (up or down).

Birman (2012) views cloud computing as an actively debated topic due to use of the word diversely by the enterprises. Some perceive cloud as related to web search, for others it is social networking while still others think of the cloud as the world's most amazing outsourcing technology, permitting users to ship data and computation to some remote place where computing and storage are dirt cheap and even more uses and meanings of the term are emerging. A search carried out on Google scholar using the term cloud computing reveals that the first articles were published in 2008. However, during 2009 few dozens of article on cloud computing attracted citations which on evaluation by AIS eLibrary were found to be irrelevant. There has been a big increase on scientific publications on cloud computing since the beginning of 2009 (cf. Armbrust, Fox, Griffith, Joseph, Katz, Konwinski, Lee, Patterson, Rabkin, Stoica and Zaharia, 2009; Buyya et al., 2009; Vaquero, Rodero-Merino, Caceres and Lindner, 2009; Weinhardt, Anandasivam, Blau, and Stoesser, 2009) but unfortunately it has been largely undefined. Zhu (2010) has referred cloud computing as "ITaaS – IT as a Service" which is bundled as a virtual end users for the end users. While, some scholars argue that cloud computing is Internet-based technology (Chine, 2010; Cubillo et al., 2011) which provides computational resources via a computer network and provides flexible, scalable, and on-demand services to the end users by centralizing the storage and network bandwidth as well as processing memory.

A report released by European Commission (Schubert and Jeffery, 2012) has put forth three perspective in an attempt to define cloud computing. From the ***users perspective*** cloud computing is an environment which extends the general internet based provisioning model with the aspects of high availability, reduced cost and ease-of-use. Another perspective deals with the ***cloud service provider purview*** who define cloud computing as a dynamic (resource) environment that guarantee availability, reliability and related quality aspects through automated, elastic management of the hosted services – the services can thereby consist in a platform, a service, or the infrastructure itself (P/S/IaaS). Lastly from ***cloud service developer view*** cloud computing is an environment which exposes services, platforms or resources in a manner that multiple users can use them from different locations and with different devices at the same time without affecting the quality aspects of the offered capabilities (service, platform, resource).

Supplementing the studies (Bristow et al., 2010) has defined cloud computing as the network of computing plants called IT factories, which are realized commercially in the form of cloud computing (Gao and Zhai, 2010). (Babcock, 2010; Durkee, 2010) view cloud computing as a form of shared – resource computing where computing is pooled in large external data-centres and accessed by a range of customers through the Intenet. Regaldo (2011) remarks that around 2007 the term cloud computing reflected the use of the internet, figuratively represented as a 'cloud' in diagrams to connect to the services. Alternative definitions offered by Boss et al. (2007) highlights the significance of access devices such as PCs and laptops (Cubitt et al., 2011), tablets, smartphones and other forms of mobile computing (Iyer & Henderson, 2011) to access the cloud based applications via an internet connection. A recent development has enabled the usage of cloud computing infrastructure through the internet enabled sensors (Pritchard, 2012). Contrary to the aforesaid arguments, (Cheng, 2010; Smith, 2009) argue that the deployment of scalable, rapidly provisioned, and metered IT assets and computing capabilities ubiquitously accessible via the Internet is known as cloud computing. In other words, cloud computing was portrayed as the manifestation of "the long-held dream of computing as a utility" (Armbrust et al., 2010, p. 50) that was proclaimed as "the new frontier of the Internet era" (Etro, 2009, p. 179). (JISC, 2010) defines cloud computing as an emerging business model that delivers computing

services over the Internet in an elastic self-serviced, self-managed, cost-effective manner with guaranteed Quality of Service (QoS).

Apart from above arguments the broad definitions on cloud computing often focus on the user perspective, in terms of what cloud computing allows individuals and organizations to do. For instance, Fingar (2009) defines cloud computing as an endless computer made up of networks of networks of computers. While, (Cagle, 2008) is of the opinion that cloud computing represents the distributed virtualization of an organization's computing infrastructure. Miller (2008) asserts that in the arena of cloud computing the applications and files are hosted on a cloud that consists of thousands of computers and servers which are linked together and is accessible via the Internet. Further, with cloud computing, everything a user does is web based instead of being desktop based. A user can access all the programs and documents from any computer that's connectedto the Internet.The world`s leading information technology research and advisory company Gartner, Inc. expounds cloud computing as a style of computing where massively scalable IT-related functions and information are provided as a service across the Internet, potentially to multiple external customers, where the consumers of the services need only care about what the service does for them, not how it is implemented. Moreover, cloud is not architecture, a platform, a tool, an infrastructure, a Web site or a vendor rather it is a style of computing which supports many for its implementation and use.

On the other hand, the narrower definitions on cloud computing tend to focus on the technical aspects of the cloud. For example, Cagle (2011) argues that cloud computing is grid computing, which uses a distributed network of servers, which work in parallel, to accomplish a specific task. A comprehensive review conducted in 2009 by the University of California Berkeley RAD Lab (Reliable Adaptive Distributed Systems Laboratory) yielded a definition that has been gaining broad popularity: "Cloud Computing refers to both the applications delivered as services over the Internet and the hardware and systems software in the data centers that provide those services. The services themselves have long been referred to as Software as a Service (SaaS). The data center hardware and software represents a Cloud" Armbrust et al. (2009).

Enabling technologies of cloud computing

Scholars feel that the cloud computing paradigm originates mainly from research on distributed computing and virtualization, as it is based on principles, techniques and technologies developed in these areas (Panizeri et al., 2011). Commenting on the enabling technology concealed within cloud computing (Mather, Kumaraswamy and Latif, 2009) argue that cloud computing is a combination of many pre-existing technologies which have come together to create a technical ecosystem. These pre-existing technologies such as processors, virtualization technology, disk storage, broadband internet connection and fast, inexpensive servers matured at different rates in different contexts making the cloud a compelling solution. While, (Weinhardt et al., 2009)feels that the only element of innovation in cloud computing is the integration of the pre-existing technologies.Moreover, cloud computing conceptually incorporates Software-as-a-Service (SaaS), web 2.0 and other technologies with reliance on the Internet, providing common business applications online through web browsers to satisfy the computing needs of users, while the software and data are stored on the servers.

Cloud computing and libraries

Library and information centres are constantly in search of low-cost and best solutions that may enable them to serve the user needs efficiently and effectively. Ironically, with the involvement with IT the commitment as well as services has been miserably infested. Under such conditions, cloud computing

is the saviour of all the ebbs of the information technology. Cloud computing is a mega change that has robbed IT of its traditional obligations and empowered the end users with on demand utility computing. Cloud-based services are set to transform the way libraries work, unleashing librarians from the admin burden to focus on services for students & researchers (JISC, 2011).“Cloud computing has become an attractive option for organizations, like libraries, that would prefer to concentrate more of their focus and funds on their core mission instead of on IT issues” (Wale, 2011). However, implication of cloud computing in libraries has been unresolved area of debate and concern in library profession. Moving from ground to the cloud is surrounded with ambivalence that whether cloud computing offers the best solution to serve the user needs or not. There has been abrupt change in the approaches of library patrons to information accessibility and delivery that have actively moved into the virtual environment. Smart phones, Mobile phones, Tablets and laptops are everywhere now. Libraries as such need to deliver resources and services in the virtual environment preferred by students, researchers, staff and faculty members or they risk alienating users. To keep pace with time libraries need to switch over to cloud and deliver content, tools and services accessible to mobile users via mobile devices. Further, there is a need to “understand better why users prefer internet tools and services such as web search engine, e-mail, blogs, and RSS feeds despite their respect for and trust in the library`s resources” (Sadeh, 2007) in redesigning the services.

Although, the development of cloud based libraries is going to take a long time it is inevitable to look at various opportunities on offer from cloud computing that necessitates its adoption. (Liu and Cai, 2013) argues that “shifting library core applications to cloud-based services will reduce or eliminate most or the entire local technical needs in managing server hardware and operating systems that underlie the applications”. Moreover, according to (Wale, 2011) “cloud computing brings along economy of scale and will help to make overall prices far more affordable for computing, storage, networking, preservation, and overall administration”. Most important to add is “Cloud computing not only benefits individual end user and companies, but also attracts libraries in many ways when they must cope with budget cuts and constrained financial resources” (Liu and Cai, 2013). Also implementation of “Cloud computing can enable more energy-efficient use of computing power, especially when the users’ predominant computing tasks are of low intensity or arise infrequently” (Baliga et al., 2010). Supplementing the above arguments (Marston et al. 2011) feels that “The impetus for change right now is seen predominantly from a cost perspective, as organizations increasingly discover that their substantial capital investments in information technology are grossly underutilized”

Recent searching on Google Trends has showed maximum interest of cloud computing in India. (Madhusudhan and Nagabhushanam, 2012) also feel that “Indian university libraries have realized the paradigm shift in library services and they are providing better web-based library services to their current techno savvy users”. Most importantly “cloud computing enables new streamlined workflows for cooperation and community building among libraries” (Goldner, 2011). According to (Sultan, 2010) Cloud computing can provide colleges and universities with a means to upgrade software and IT hardware attracting students and keeping pace with digital technological developments. On the other hand, (Scale, 2010) puts forth his view that “Cloud computing is currently enabling librarians to shift from the paradigm of ownership and maintenance of resources towards the provision of access to information maintained and controlled by others”. There is a general misconception that moving the library into cloud will eradicate the need of library IT staff as all works will be done by cloud service provider. Although cloud computing involves more responsibilities and obligations of the service provider yet, “cloud based service is not entirely plug and play and the client library need worry only about such things as local bandwidth, hardware client (PCs) and software configuration” (Prince, 2012). According to (Sorensen and Glassman, 2011) “Cloud-based applications offer libraries new

ways to present information or offer services that were previously unaffordable or unavailable". (Patel et al., 2012) have enlisted four core areas of cloud computing solutions in the libraries: technology, data hosting archives, information and community.

Simultaneously, various scholars have argued that cloud computing was already in practice before the concept gained momentum and there are ample possibilities in the future. For instance, Hoy (2012) asserts that many library patrons are already using cloud products such as Gmail, Google Docs and bibliographic management tools for their daily needs. He further says that number of applications available in the cloud has increased substantially in recent years. On the other hand, Cohn et al. (2002) opines that libraries use database vendors or integrated library system providers who provide external servers to host library software and data in the cloud. (Romero, 2012) argues that "in the field of library automation there are several commercial suppliers already offering various adaptations of their products which make the use of the cloud possible to a lesser or greater extent". According to (Prince, 2011) some of the "cloud-based options for libraries include IaaS or PaaS-hosted ILS systems in which libraries buy their ILS software from one vendor and host it on another vendor's servers". Major ILS vendors exclusively having SaaS deployment options for libraries are: ExLibris, VTLS and CyberTools.

Commenting on the future prospects of cloud based library services, (Wale, 2011) argues that "Discovery tools can be embedded in commonly used applications such as course management systems and institutional portals, enabling libraries to meet the needs of users wherever they are". According to (Luo, 2013) virtual reference services and research guides can be provided in libraries through software such as LibChat, QuestionPoint and LibGuides which are all hosted on the cloud. Further, there are various cloud based tools for reference service needs of the libraries such as "cloud-based video services" (e.g. YouTube, TeacherTube), "information collection services" (e.g. Google forms) and "file sharing services" (e.g. Dropbox). The revolutionary development to cloud based library services is WorldCat Local where "OCLC along with Google are exchanging data in the cloud to facilitate the discovery of library collections through Google search services in a single interface" (Jordan, 2010). However, the biggest impediment of adoption of cloud computing "lack of functionality of traditional counterparts" (Marston et al., 2011) in cloud computing. Also, "Librarians in many developing world libraries are disadvantaged encountering connectivity challenges because funding cloud computing platforms or enhancing bandwidth are not always priorities in these regions as there are more immediately urgent problems for funders to deal with such as hunger" (Mavodza, 2012). In order to develop a cloud based library there is a need of librarians` training and practise in order to address the issues of cloud in reality.

Benefits of cloud computing in libraries

In the available literature cloud computing has been discussed as a new technology that can provide several advantages, both strategic and operational, to its adopters;however the cloud computing adoption rate is not growing as fast as expected (Banerjee, 2009; Buyya et al., 2009; Goscinski and Brock, 2010). One of the primary benefits of Clouds is cost reduction (Sobel et al., 2008; Powell, 2009; Pocatilu, 2010; Cubillo et al., 2011). Cloud computing reduces the cost involved in the IT-based services by the organizations and freeing them from the expense and hassle of having to install and maintain applications locally (Leavitt, 2009). Apart from these benefits cloud computing has the potential to decrease the expense of capital through the virtualization of computing infrastructure and the resources (Kondo et al., 2009; Nandi et al., 2010); increase the optimal resources availability and utilization (Chahal et al., 2010); save time (Ekanayaka and Fox, 2009; Ramani, 2011); energy consumption (Berl et al., 2009; Richards et al., 2010; Ferzli&Khalife, 2011); infrastructure building

(Basak et al., 2010; Hofmann, 2009). Moreover, with the use mobile devices to access the cloud resources can save the mobile`s battery (Gember&Akella, 2010; Miettinen&Nurminen, 2010; Zhu et al., 2011) and the needed solution can be easily accessed.

Pyke (2009) has put forth several benefits of cloud computing such as, scalability, ease of implementation and freeing up of internal resources, and quality of service. Due to the benefits like availability, scalability, agility, elasticity, and on demand services cloud computing can be efficiently used to enhance the learning environment (Rajaei and Aldakheel, 2012).They further add that cloud-based education also known as blended e-learning builds the learning environment through the cloud services where the platform has dynamic and scalable capabilities and can be customized through the IaaS and PaaS services.In addition, some scholars highlight the significance of data processing and the availability of complex applications that can be proved useful to a wide range of the scientific disciplines such as e-science (Mustafee, 2010; Fox, 2011; Truong &Dustdar, 2011) and climate research (Evangelinos& Hill, 2008). Further, (Veni and Masillamani, 2010) argue that cloud computing with its remote management ability has lent efficiency for effective collaboration, communication and resource sharing. The available cloud based collaboration tools and applications can be used in the course of information sharing and imitating the works of others (He et al., 2010; Richards et al., 2010).

The major benefit for any end user is of course that cloud computing can be used simply whenever you need it (Kunze et al., 2008). Furthermore, within a cloud computing system maintenance costs on the hardware is not involved (Velte, 2009). (Vecchiola 2009) opines that the cloud is filled with applications that are ready to use, and more important the data used in this application is always accessible from anywhere in the world.According to (Bakker, 2011) in nutshell cloud computing provides a combination of economic and performance benefits which lies in the costs that have to be made whenever an organization needs additional IT services, and this relates to the performance benefits. Further, the extra performance can be acquired whenever necessary which can improve the performance of an organization directly.Apart from cost benefits cloud computing provides users a power of choice among less expensive (or free) competing services that are user-friendly, accessible from any location, and more reliable (Bristow et al., 2010).

Other expected benifit of embedded cloud computing services includes the faster speed of business communications, efficient coordination among firms, better customer communications and effective access to market information mobilization (Armbrust et al., 2010; Hayes, 2008). However, firms may not have confidence in a cloud computing system because it is relatively new to them (Buyya et al., 2009). It may take users a long time to understand and implement the new system. On the other hand, (Moulasion and Corrado, 2011) argue that if librarians can save on buying and maintaining servers, they can save their parent institution money. Depending on the service, they can also rely on the software provider to carry out all updates, thereby allowing their own employees to take care of other obligations in lieu of monitoring version changes and upgrades. Furthermore, quite a few of the cloud-based software platforms are available for free, meaning that librarians can make use of services without incurring any cost for their libraries. According to (Hall-Coates, 2013) organizations such as libraries which amass large volumes of information may also benefit from the relative security of cloud computing storage, given the ease at which physical documents, hard drives/thumb drives, and digital devices can be misplaced, lost, or stolen.(Broberg et al., 2008) adds that cloud computing storage and delivery services have significantly reduced the cost, thus presenting a valuable solution during the current financial crisis to enable the institutions to maintain the quality of services (Mircea, 2010).

Another line of thought presented by the scholars depicts the green IT benefits of the use of cloud computing applications. For instance, (Issa, Chang and Issa, 2010) opines that with cloud computing, organizations are bound to save hardware and maintenance cost, reduce CO2 emission and promote Green IT for a smarter business and smarter planet.

Risk and challenges of cloud computing in libraries

Although the available literature highlights many benefits of cloud computing yet it suffers from many risks and challenges during the course of its implementation. Like every technological concept, cloud computing is not an exception in terms of trust and security issues. Most of the risks associated with cloud computing are from the customer's point of view as the data is owned, controlled and processed outside of the organization which logically brings a certain amount of risk, because in a sense it is a form of outsourcing (Ahmed & Othman, 2013). Data processing causes to shift any form of security from the organization to the outsourced organization (Lacity & Hirchheim, 1993) which mandates the acquaintances with risk procedures beforehand. On the other hand, (Brodkin, 2008) presumes that within a cloud computing environment what stays important is that most cloud users (clients) are usually not aware of the complete policy and thus do not know very well what risks they are exposed to when entering their data into the cloud. (Shen and Tong, 2010) feels that during the course of adoption of cloud computing security is a big concern due to the availability of different systems that may be working in a multiple environment. Additionally, with the proliferation of mobile and personal devices like smartphones and tablets there has been an increase in the cloud based storage services like Google Drive, Dropbox or Microsoft Dropbox which has raised the issues of data privacy, confidentiality putting the user at a legal risk (Catteddu et al., 2009; Hoboken et al., 2012). Once data are outsourced to a third-party cloud provider, several concerns arise about security, availability and reliability of data (Tsaravas and Marinos, 2011). While (Dogo, Salami and Salman, 2013) also feel that data integrity, trust, privacy, expectations, control, regulations, intellectual property management, audit trails, service-metering and performance are some of the critical concerns associated with cloud computing.

Catteddu (2009) has put forth three issues that are critical implementation of cloud computing which includes technical, legal and organizational policy.Another important form of risk for a cloud is a so called flooding attack(Yaar, 2004). In general, flooding attacks are to be seen as a huge amount of requests for a service. A “hacker” sends many request to a server which the cloud hosts. All these request are in fact fake and have the goal to get the cloud offline. It tries to make so many requests for a particular service that the server cannot cope with the amount of request so it goes down.(McIntosh 2005) feels that these attacks are common in a cloud computing environment as cloud computing could also be web based which exposed to this problem. These forms of hack are usually used to obtain data without having the rights to access them (Pietraszek 2006).Further, Nathuji et al. (2010) observes that the performance of an application hosted in a Cloud environment can be heavily affected by the existence of other virtual machines hosting other applications on a shared server.

(Miller, 2008, Jeffrey and Neidecker-Lutz, 2009, Ristenpart et al., 2009) have enlisted a number of challenges in the cloud computing arena such as: a constant internet connection, slow internet connections, limited features offering, security, danger of data loss or cloud vendor filing for bankruptcy.(Moulasion and Corrado, 2011) supplement the arguments and claim that the services that libraries can acquire through the use of cloud computing platforms may indeed be valuable, but the cost of internet access, even if bandwidth is not currently at a premium, can become a considerable hurdle to effective provision of services”. However, commenting on the challenges associated with cloud computing Carr (2005) remarks that the biggest impediment to cloud computing will not be

technological but attitudinal. Complexity of an innovation can act as a barrier to implementation of new technology; complexity factor is usually negatively affected(Premkumar et al., 1994). Ramgovind et al, (2010) feels that as computer manufacturers, employers and universities deploy cloud based tools on desktops, many users may fail to realize that they are in fact using an Internet based service. This risk of confusion will likely increase when cloud based applications lack any recognizable browser branding, and continue to function when the user is not connected to the Internet.Katz (2009) focuses on many areas where the cloud may impinge on education. He advocates that because companies might be storing documents which should not be made public, there are reasons for concern about what can happen to the information. Potential Cloud organisations and vendors need to be aware that it may become easier for attackers to threaten clouds by moving towards a single cloud interface. Despite the potential benefits and revenues that could be gained from the cloud computing model, the model still has a lot of open issues that impact the model creditability and pervasiveness. Vendor lock-in, multi-tenancy and isolation, data management, service portability, elasticity engines, SLA management, and cloud security are well known open research problems in the cloud computing model (Morsy, Grundy and Muller, 2010).

Case studies of cloud computing in libraries

Some of the notable case studies carried out to deploy cloud computing solutions are:

- Boston University (BU) Cloud Initiative, U.S.A.

Funded by National Science Foundation grants BU has took initiatives in distributed/ CC that aims to offer an open marketplace to independent, rational parties interested in setting up their own applications. They are exploring the competencies of Colocation Games[5] to develop an economically-sound framework upon which emerging cloud architecture could be implemented.

- Carnegie Mellon University (CMU) Cloud Initiative, U.S.A.

CMUis host to several CC research programs. CMU has joined hands with silicon valley based researchers to address the need for industry-wide, globally accepted measures for calculating the benefits and risks of CC services. Development of standards and measures to determine the cost, risks, quality and performance for CC services is also on top priority. Further, CMU in qatar along with IBM (International Business Machines Corporation) is working on Cloud Computing Lab[4] (CCL) research initiative from 2009 to bring CC to the middle east. It focuses on performance analysis of scientific workloads, with regional relevance, on the cloud as well as solutions to overcome current limitations of the existing cloud paradigm.

Also, Intel Science and Technology Center for CC[10] (ISTC-CC) has been formed as an open community to devise critical new underlying technologies for the cloud computing of the future. It is headquartered at CMU that includes researchers from GeorgiaTech, Intel, Princeton and UC-Berkeley. Also, researchers at CMU are using CC for multi-tier indexing of Web search engines. They are using CC to characterize the topicality of web content to more effectively process web searches. Routing searches topically requires less effort than traditional searches, enabling significant computational and financial savings. The project is using the Google/IBM cluster to ‘crawl’ the web and perform the data cleansing and pre-processing necessary to develop a web dataset of 1 billion documents to support the research. The web dataset is also being made available to the larger information retrieval community to multiply the impact of the project on that discipline.

- Duke University (DU) Cloud Initiative

Funded by National Science Foundation in collaboration with NCSU, UNC Chapel Hill, and NCAT State University to explore and test Trustworthy Virtual CC Duke University has created a trustworthy virtual cloud super-computing environment for researchers. DUs Scalable Computing Support Center[2] has developed two options for CC:

- Private Duke Cloud, where researchers can purchase high-priority cycles as needed from a pool of machines and pay per CPU hour.

- Economy Cloud, where researchers can purchase low-priority cycles only, for a lower per CPU rate.

Researchers pool existing resources and share access to greater computing power than they could afford on their own, without worrying about the 'care and feeding' of the equipment, since DU provides the physical space, systems administration, programming assistance, and power and cooling for the machines.

- Florida International University (FIU) Cloud Initiative

FIU researchers are leveraging CC to analyze aerial images and objects to help support disaster mitigation and environmental protection. Prominent researches carried in the CC domain include creation of virtualized infrastructure systems and applications laboratory and Verification based Integrity Assurance Framework (VIAF).

- Indian Institute of Technology (IIT) Cloud Initiative, Delhi

In India, IIT has played a pioneering role and is the earliest adopter of CC solutions. IIT Delhi has developed Baadal in 2011, which is indigenously developed cloud orchestration and virtualization management software that can work with multiple virtualization technologies like KVM, Xen and VmWare. Further, IIT Delhi has CSC has commissioned ownCloud, a file and document sharing utility similar to the popular dropbox, for use by the IIT Delhi community. The utility supports storing and sharing of files, images, music and documents, contacts, calendar, tasks etc. It also supports version control and syncing with Windows/Linux/Mac desktops and Android and iOS based devices.

Baadal is still in its beta phase which is based on:

- 32 blade servers each with 2x6 core Intel(R) Xeon(R)

CPU X5670 @ 2.93GHz and 16 GB RAM.

- 16 blade servers each with 2x4 core Intel(R) Xeon(R)

CPU E5540 @ 2.53GHz and 12 GB RAM

- A 10Gbps ethernet backbone

- 50 TB of virtualized storage based on a NetApp 3210V

NAS and HP EVA6400 SAN with FC disks.

- Open source virtualization technology based on KVM.

- Indiana University (IU) Cloud Initiative

The researchers at IU are working on several CC projects with grants from the National Science Foundation (NSF) and the National Institute of Health (NIH). Their research includes Large-Scale Distributed Scientific Experiments on Shared Substrate[15], Exploring the use of cloud techniques to overcome current medical computing obstacles such as long computation time and large memory requirements; and The FutureGrid project that will provide an experimental platform that accommodates batch, grid and CC.

- Massachusetts Institute of Technology (MIT) Cloud Initiative

MIT[5] in collaboration with Yale University (YU)and the University of Wisconsin at Madison are working on comparative study of approaches to cluster-based, large-scale data analysis funded by NSF. In addition they are also independently studying CC Infrastructure and Technology for Education.

- North Carolina Agricultural & Technical State University (NCATSU) Cloud Initiative

The team at the NCATSU is conducting research, funded by a NSF, in collaboration with NCSU, DU, and the University of NC at Chapel Hill to explore and test Trustworthy virtual CC.

- North Carolina State University (NCSU) Cloud Initiative

NCSU and IBM have developed VCL (Virtual Computing Lab) to provide every student with most advanced educational resources. Through cloud infrastructure students will be provided accessibility to most advanced educational materials, select software applications and computing and storage resources.The VCL solution allows users to remotely access a desired set of applications and environments over the Internet using a personal computer, laptop or mobile device from anywhere, at any time. To VCL users, even the most demanding software applications, operating systems and environments are easily accessible through license-honoring technology in a click of the mouse. Access is instant, and offers a range of options from single desktops to classroom-sized labs, to collections of servers and storage, to high-performance computing clusters.

Further, NCSU is engaged in several CC projects funded by the NSF which includes two collaborative studies on Trustworthy Virtual CC and Hybrid Opportunistic Computing for Green Clouds.

- Purdue University (PU) Cloud Initiative

The project at Purdue University is investigating linguistic extensions to MapReduce abstractions for programming modern, large-scale systems, with special focus on applications that manipulate large, unstructured graphs. This will impact a broad class of scientific applications. Graphs have important utility in the social sciences (social networks), recommender systems, and business and finance (networks of transactions), among others. The specific case study targeted by the research is a comparative analysis of graph-structured biochemical networks and pathways which underlie many important problems in biology. They are also providing a CC testbed called Wispy to TeraGrid users.

- Tsinghua University (TU) Cloud Initiative, China

TU is the first prestigious university in mainland China to join Google's CC related programs and to work with Google on the offering of data processing courses and the research on CC. They have developed TU Cloud which is an all in one CC solution developed at the Grid Computing Division of TU in China that comprises of three components: Nova (virtual computation system: computing cloud), Carrier (distributed file system) and Corsair (distributed file manager based on carrier: storage cloud), which can be utilized independently or in combination.

- University of California (UC) Cloud Initiative, Irvine

Funded by NSF, UC Irvine is working on a project to provide support for efficient fuzzy queries on large text repositories in the cloud. Supporting fuzzy queries can ultimately help applications mitigate their data quality issues because entities with different representations can be matched for example 'PO Box' vs 'P.O. Box'.

- University of California (UC) Cloud Initiative, San Diego

Researchers at the UC, San Diego are studying how to manage and process massive spatial data sets on large-scale compute clusters. This research will use the LiDAR topography data hosted by OpenTopography as a test case and will focus on how CC can aid the management and processing of massive spatial data sets.

- University of California (UC) Cloud Initiative, Sant Barbara

The UC is actively pursuing several advancements in CC. Their Massive Graphs in Clusters (MAGIC) project is focused on developing software infrastructure that can efficiently answer queries on extremely large graph datasets. They have also designed an open-source implementation of the Google AppEngine interface.

- University of Maryland (UM) Cloud Initiative, College Park

The research team at the UM, CC Center at College Park is working on a range of projects funded by the NSF. They include a Hadoop Toolkit for Distributed Text Retrieval, Data Intensive Text Processing, Commodity Computing in Genomic Research, and a series of other independent studies.

- University of Massachusetts (UM) Cloud Initiative

CC research in University of Massachusetts involve the Google/IBM cloud to learn more about world relationships which is funded by NSF.

- University of Melbourne (UM) Cloud Initiative

The CC and distributed systems laboratory at UM is actively engaged in the design and development of next-generation computing systems and applications that aggregate or lease services of distributed resources depending on their availability, capability, performance, cost, and users' quality-of-science requirements. The lab is working towards realizing this vision through its two flagship projects: Gridbus and Cloudbus.

- University of Minnesota (UM) Cloud Initiative

Researchers at UM are developing a cloud proxy network that allows optimized and reliable data-centric operations to be performed at strategic network locations.

- University of North Carolina (UNC) Cloud Initiative, Chapel Hill

In collaboration with NCSU, DU, and NCAT State University, researchers at the UNC are trying to explore and test trustworthy virtual CC environment.

- University of Utah (UU) Cloud Initiative

The researchers at the UU are working jointly with University of Washington(UW) on building a new infrastructure for computational oceanography that uses the Google/IBM cloud to allow ad hoc, longitudinal query and visualization of massive ocean simulation results at interactive speeds.

- University of Virginia (UV) Cloud Initiative

The team at the UV is working on several CC projects funded by the NSF. They include, feedback controlled management of virtualized resources for predictable e-science and image super-resolution using trillions of examples.

- University of Washington (UW) Cloud Initiative

The researchers[5] at the UW are working jointly with UU on building a new infrastructure for computational oceanography that uses the Google/IBM cloud to allow ad hoc, longitudinal query and visualization of massive ocean simulation results at interactive speeds. Further, their Astronomy Survey Group is conducting research to scale the sky with MapReduce/Hadoop.

- University of Wisconsin (UW) Cloud Initiative

The UW have designed the hierarchically redundant, decoupled storage project (HaRD) to investigate the next generation of storage software for hybrid Flash/disk storage clusters. They are also working with MIT and Yale University (YU) on a comparative study, funded by a NSF CLuE grant (Cluster Exploratory Grant), of approaches to cluster-based, large-scale data analysis.

- Wayne State University (WSU) Cloud Initiative

Wayne State University is working on developing a unified learning approach, namely URL, to automate the configuration processes of virtualized machines and applications running on the virtual machines and adapt the systems configuration to the dynamics of cloud. Further, they have started Wireless health initiatives that attempts at applying sensors, wireless communications and CC to healthcare applications.

- Yale University (YU) Cloud Initiative

The team at YU is working in collaboration with MIT and the UW at Madison on a comparative study, funded by a NSF, CLuE grant, of approaches to cluster based, large-scale data analysis.

Migration strategy for academic library

Specialised frameworks and models of cloud adoption

(Ogbu and Lawal, 2013) developed a model for the delivery of electronic resources in the cloud for Nigerian universities. In this model, Nigerian universities instead of owning physical server rent a server in the cloud. This physical server contains the electronic resources of the universities which are retrievable through a common cloud based web OPAC and is compatible with any devices which have a web browser.

Another study carried out by (Min, 2012) proposes a framework for smart libraries built on cloud computing. The smart library model combines the existing library functions with the knowledge based e-learning system to develop human resources. It enables the library users to develop their collective

intelligence-based learning knowledge base using a collaborative and interactive interface, and which promotes self-managed learning to improve the creativity and logical thinking. According to (Min, 2012) while the existing library information service emphasizes the 1:n online knowledge service provided by library personnel, the smart library system can create, validate and categorize knowledge using collective intelligence group and provide intelligent knowledge, realistic knowledge, customized knowledge, and hands-on knowledge. A smart library information service system provides the service converged with the intelligent tutoring system, as well as adding an intelligent learning engine, collective intelligence interactive interface, knowledge-base manager, and open framework technology to the conventional library information service system.

The first model for the cloud based library services is proposed by (Dhamdhere and Lithikar, 2013). Through this model the library materials for different courses can be hosted in the cloud. These library materials can be managed through a library management solution that enhances the dissemination of the library resources.

Mircea and Andreescu (2011) suggests five stages for migrating strategy towards cloud which includes:

a. **Developing the knowledge base** about cloud computing through attending seminars, workshops as well as conducting discussions with the suppliers and consulting the mostr ecent researches in the field.

b. **Evaluating the present stage of the institution** from the point of view of the IT needs, structure and usage. This stage will help the institution to understand which data, services, processes and applications that may be migrated or need to be maintained within the institution.

c. Experimenting the cloud computing solutions which can be done gradually as pilot test projects, and thereafter scaling it to all users in the institution.

d. Choosing the cloud computing solution. At this stage, institutions are required to conduct thorough evaluation to compare cloud service providers' capabilities, licensing mechanisms, and pricing models in order to make sustainable choices. The choice will also depend on cloud deployment options.

e. **Implementation and management** of the cloud computing solution.

Cloud computing use cases

Survey studies conducted by IBM suggests that 90% of business and technology leaders expect to implement some cloud computing by 2015 while 40% expect to implement substantially (Berman et al., 2012). Another survey conducted by Horses by sources reveals that nearly two-thirds of business and IT executives view cloud as an enabler of service delivery models that drive innovation in their organizations and the key decision makers are prepared to devote 30% of their IT budgets to the implementation of cloud services over a five year time frame (Horse for Sources, 2010; Willcocks et al., 2011). Forrester forecasted a global market for cloud computing of $61 billion for 2012 (Kirsker, 2012) which is believed to grow to $241 billion by 2012 (Dignan, 2011).The University of Delaware Library isthe first academic research library and the first member of the Association of Research Libraries (ARL) to implement the OCLC WorldShareManagement Services. OCLC WorldShare Management Services

Standards and Regulations for cloud computing

Academic libraries can choose to migrate to cloud owing its many benefits. But, due to the amorphous nature of the cloud there are many issues which need to be addressed in due course of time. According to (Mazumder, Rakib and Uddin, 2012) being able to keep important data secure has always been a priority in IT, but as cloud computing takes information outside of the virtual secure walls most corporations have raised red flags to its adoption. The problem is further aggravated as the standard apex body International Organization for Standardization (ISO) claims to have developed 19,500 standards on different aspects in the world till date but no standards have been developed yet on cloud computing. Giving the concern a prime importance legislations and guidelines with the cloud service provider should be framed. These issues demands for a well-established set of standards that can address the cloud computing phenomena before its implementation in the libraries.

A survey report released by Ernst and Young (2012) claims that India is at higher risk when operating as a cloud computing service provider due to the lack of treaties and undeveloped tax laws on cross-border transactions that may cause adverse tax consequences.Commenting on the possibilities of implementation of cloud computing in libraries (Yuvaraj, 2014) asserts that although the future of cloud libraries is very cloudy but seeing the trend denial of cloud computing will strip users from the brick-and-mortar libraries but before its implementation there is a need to frame "*Canon of Cloud Libraries*" that should be the guiding principle for the alliance of libraries with Cloud computing. He further adds that the Canon of cloud libraries should address the problem of cloud library legislations, define the scope and boundaries of the library services in the cloud and resolve the issues of data loss, privacy, migration and backups.

However, in the recent years Institute of Electrical and Electronics Engineers (IEEE) are working on two groups P2301 (10) and P2302 (11) in order to standardize the aspect of cloud computing services. P2301provides a roadmap for all cloud providers building services under the standard while P2302 defines topology, protocols, functionalities and governance required for cloud interoperability and cloud federation that will ensure the ability of exchange data between clouds (Nguyen, Tran and Hluchy, 2012).Other projects carried out to standardize cloud computing practises are EU FP7 programme (Contrail project homepage, n.d.), 4CaaSt (Eu fp7 programme, n.d.) project targeted towards the creation of software libraries for PaaS (Platform as a Service) that will ease the development of applications, Contrail (Loutas et al., 2010) project that aims to promote an open source system for Cloud Federations, Vision Cloud that aims to encapsulate storage into objects with metadata, extending the limited data migration capabilities, Cloud4SOA (Menchtas, Gatzioura and Varavarigou, 2011) project that deals with semantic interoperability issues within the cloud on various levels.However, despite the availability of existing standards like OCCI (Open Cloud Computing Initiative) (22) and DTMF`s OVF (Open Virtualization Format) (1) it is almost impossible to move applications between the different cloud providers (e.g. from Amazon (5) to Force.com (14)) as each provider has their own proprietary data structure and all providers especially who already have a substantial market share do not take interest to make their services interoperable (Nguyen, Tran and Hluchy, 2012).

(Bradshaw, Millard and Walden, 2011) have enlisted four kinds of documents that should be framed in order to standardize cloud computing practises which includes:

a) **Terms of Service** (ToS) – Detailed description of the relationship between the cloud services user and the provider.

b) **Service Level Agreement** (SLA) – Specification of the level of service the provider aims to deliver together with the process for compensating customers if the actual service falls short of that.

c) **Acceptable Use Policy** (AUP) – Detailed description of the permitted (or in practice, forbidden) uses of the service.

d) **Privacy Policy** – Description of the provider's approach to using and protecting the customer's personal information.

Cloud based library services

There are enormous possibilities in libraries on a cloud computing platform. Scholars have put forth various avenues where libraries can benefit themselves and justify themselves in the changing paradigm. (Bushhousen, 2011) feels that as the digital and physical worlds continue to merge, people expect and increasingly rely on information services around the clock making cloud computing a viable solution to be explored. From a technological and access standpoint, a large portion of what a library does could be done in the cloud, releasing librarians' time for other pursuits (The Digital Shift, 2012).According to (Singh and Veralakshmi, 2012) cloud can be used as an environment for scholarly communication, collaboration, discovery, publication, and dissemination of scholarly works. The libraries can apply cloud computing to data integrity, upgrade and maintenance, intellectual property management, backups, disaster management, and failover functions.With resources becoming digital and accessible outside of library collections libraries are attempting to adapt to remain relevant by utilizing cloud computing and providing access to digital resources from outsiders (Scale, 2010). Moreover, India's problem of vast illiteracy and low levels of education at school level can be solved by cloud computing through NCERT or ICSE clouds where CBSE courseware, educational material and books could be hosted in the cloud organised through digital repositories by the librarians which can be downloaded from any place at a far less cost being shared by millions of students.

For the libraries cloud-based services are another way library patron interacts with the information which makes it inevitable for the librarians to make themselves acquainted the way information is stored, managed and delivered in the cloud (Bushhousen, 2011). Goldner (2010) on the other hand summarizes that the main focus of libraries moving into the cloud has been discovery services, that is, the need to disclose libraries' vast collections on the Web. Mitchell (2010) shared the Z. Smith Reynolds Library's experience of migrating key IT services (e.g., OpenURL resolver, journal listing service, instructional guides, ILS, and institutional repository discovery layer) to cloud-based environments. These case studies offer a concrete view of how to implement cloud solutions in libraries and how to leverage these technologies in library operations. According to (Luo, 2013) other areas where cloud solutions can be beneficial include:

• Acquisitions librarians managing increasingly diverse collections;

• Cataloguing librarians seeking to describe an ever-increasing body of information and information sources that library is managing;

• Serials librarians working to maintain control and access to collections spread across the Web;

• Electronic resource librarians managing burgeoning collections and ever changing lists of vendors.

According to (Breeding, 2011) libraries are already using cloud computing for day-to-day functions and the newly designed library integrated library system are designed with the cloud in mind that is

based on SaaS model. Other uses of cloud computing in the library include OpenURL-linking software and instructional materials such as LibGuides. Complementarily, OCLC is creating a web-scale management service to provide a unified library system "in the cloud," complete with circulation, acquisitions, delivery and license management services in addition to its catalogue interface (Hawaii Library Association, 2010). The findings of a study carried out by (Luo, 2013) to examine the pattern of use of cloud computing technology by the reference librarians of US reveals that cloud computing is being used by the librarians for a variety of purposes ranging from facilitating internal communication and collaborative work, to supporting information literacy instruction. Other library functions that are being moved into the cloud are cataloguing, statistics, tracking, bibliographic management and reference question tracking tools (Hoy, 2012). (Yuvaraj, 2014) lists various ranges of services that can be offered via the Cloud computing enabled libraries which include:

- Cloud-based access to library collections through the OPAC
- Delivery of services as well as documents as an utility
- Just-in-time during need on demand library services
- Cloud based recommender system to make user friendly retrieval strategy, for example Bibliocommons
- Cloud based discovery layers to make the special collections of the library accessible to users which are not catalogued.
- Cloud based software of citation management enables users to share content, form communities and recommend a resource.
- Cloud based efficient management and organization of scholarly communications.
- Cloud based library apps enrich user to access the library data.
- Cloud based Stack Map, shelf-mapping software enable users in mapping the physical location of a book.
- Appealing feature of Cloud libraries services includes global accessibility to vast library resources and the inherent resilience to failures.
- Cloud library services are metered that integrates telemetry as a part of service offerings.
- CAS and SDI services through emails, RSS feeds or web feeds, Social networking websites and blogs
- Cloud based self-service for real time queries
- Global Cooperation in maintaining bibliographic and authority records
- Global collaboration on decision on collection development, preservation and digitization.
- Collaborative management of Cloud resources

Cloud based architecture

Jericho forum (2009) has proposed cloud cube model to explain the cloud formations for an efficient collaboration. The four dimensions of the cube are representative of the manner in which the cloud can be provisioned.The cube represents the cloud resources which are made available by the cloud service provider. The first face of the cloud represents the physical location of the data (Internal/ External), second face represents ownership (Proprietary/ Open) of the cloud technology while the third face represents the area of IT operation (Perimeterised/ De-perimeterised) i.e. whether the operation is within the traditional IT perimeter or outside it.

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