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Cloud Computing: A Promising Economic Model for Library and Information Centers

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ABSTRACT

Till 1970s, Indian libraries were mainly dependent upon their own resources to meet their users' information needs. Then came an era of computerisation where libraries started working in a collaborative manner being connected through networks or consortia to utilise the resources of participating libraries also. Now cloud computing is emerging as a new technology which is becoming popular for scholarly communications in different types of organisations, particularly in corporate organisations. In this context, the article reviews how far cloud computing is suitable in libraries and the extent to which its applications and services can be used. The authors believe that India is self-sufficient now as it has the adequate technology and skills to bridge the digital divide. The cloud computing model would enable libraries to maintain better control over the applications and the data stores containing sensitive, private information. In addition, it helps the users to maintain their personalised information. Infrastructure virtualisation and cloud computing are becoming attractive choices being challenged by growth in the size of collection, new formats and dynamic usage. Hence, it is high time for the libraries to focus and avail the advantages of cloud computing to offer user-centered multi-level services to enable them to achieve greater level of satisfaction.

Keywords: Cloud computing, architecture, platforms-as-a-service, infrastructure-as-a-service, software as a service

1. INTRODUCTION

Libraries since their inception have been disseminating the knowledge by providing different types of services but at that time they were totally dependent upon their own resources. However, with the introduction of technology, the scenario has totally changed as today they can provide information 24x7, crossing all the geographical boundaries. This was possible because of the use of computers and accessing the networking and consortia. So libraries are now focusing on appropriate, tailored, timely, and multi-level services for their users by using different service models such as, WWW, FTP, BBS (Bulletin Board Service), and e-mail. However, with the fast technological developments, users' information requirements are becoming more and more personalised so libraries are entering into a new era of using newer technology, i.e., cloud computing which offers user-centred personalised services, leading to greater satisfaction among users.

The buzz around cloud and virtual computing has grown almost simultaneously as well as exponentially as a revolution to change the use of internet and information system. Cloud can be used as an environment for scholarly communication, collaboration, discovery, publication, and dissemination of scholarly works. Because of these features, virtualisation, and cloud computing are gaining growing acceptance around the world to have efficient service delivery in a cost-effective manner. It is a landmark development after the integrated (networked) computer systems and the internet. Adoption of cloud computing is slowly increasing, particularly in corporate organisations that require more adaptability and flexibility in response to outgrowing needs of IT industry. As a result, it is emerging as an extremely popular model for providing the demand-based virtualised resource service which being internet-based, not location-specific and accessible from anywhere 24x7. Virtual advanced technology helps to remotely communicate and deliver data to clients. Such services are based on virtual resources which are networked, independent of common location, accessible from anywhere without any concern about their ownership and management. Present environment raises challenging issues in organising and managing the physical resources to explore their efficient utilisation in different activities. For this, cloud computing

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offers individuals to personalise their environment in which they work or learn. So this is an accessible resource of hardware, software, and the artifacts stored in the cloud that can be accessed or shared through Internet from anywhere at any time.

Cloud computing has greater educational potential at affordable cost to advance the scholarship of teaching and learning programmes[1]. India's problem of vast illiteracy and low levels of education at school level can be solved by cloud computing[2]. Dhawan further adds that NCERT or ICSE clouds can be there with CBSE courseware and books, and the students can download educational materials from any place at a far less cost being shared by millions of students.

2. WHAT IS CLOUD COMPUTING?

Cloud computing is a new technology which is an improvement of distributed computing, parallel computing and grid computing. The basic principle of cloud computing is making tasks distributed among large number of computers but not in local computers or remote servers[3]. This is a dynamic model, based on pay-per-use (subscription) or scalable system in which configuration of resources (hardware, platform/services) can be graded to suit the needs of the users for optimum utilisation of resources. In simple words, it is a subscription-based or pay-per-use real time service over the internet[4].

The vendors of this model also guarantee the utilisation of these virtually interconnected resources by employing customised-service-level agreements (SLAs). According to Geelan[5], cloud computing is the user-friendly version of grid computing. However, Buyya[6] *et al*. have given much more elaborate definition which reads that cloud computing is a kind of "parallel and distributed system consisting of a collection of interconnected and virtualised computers that are dynamically provisioned and presented as one or more unified computing resources, based on SLA established through negotiation between the service provider and consumer".

Cloud computing takes the concept of virtualisation even further by adding a couple of additional twists. In a cloud computing environment, the organisation running an application neither typically own the physical hardware used for the applications nor usually know exactly from where the computation work of the applications is being processed. Cloud computing provides an organisation with appreciably more flexibility and scalability to satisfy computing needs[7]. Thus cloud computing means sharing and use of applications and resources of a network environment to get work done without concern about ownership and management of the network's resources and applications[8]. This is a way to increase capacity or add capabilities without investing on new infrastructure, training new personnel, or licensing new software.

3. EMERGENCE OF CLOUD COMPUTING

Emergence of cloud computing can be traced back to 1969, when Leonard Kleinock, the chief scientist of ARPANET who invented internet said, "as of now, computer networks are still in their infancy, but as they grow up and become sophisticated, we will probably see the spread of computer utilities which like present electric and telephonic utilities will service individual homes and offices across the country"[9]. This vision of Kleinock has come true in this economically constrained dynamic environment when many organisations are being forced to cut down their cost on IT management by adopting cost effective tools and technologies like cloud computing.

Hartig[10] indicates that the concept of cloud computing is derived from the imagery of the 'internet cloud', in which the imagery of a cloud is traditionally used to represent the internet or some large networked environment. According to Sharif[11] this is a major revolution, second only to the invention of the printing press. According to Sanchati & Gaurav[3], cloud computing is a completely new IT technology, known as the third revolution after PC and Internet in IT. Indeed the concept of cloud computing emerged from distributed grid and utility computing systems.

4. CLOUD COMPUTING INFRASTRUCTURE

The cloud computing infrastructure resides in a large data center, managed by service providers who offer computing resources anywhere, any time at an economically affordable cost i.e. 'pay-as-you-go basis'[11]. According to Hand[12], in cloud computing, not just the data but the software also resides within *cloud,* and one can access everything not only through our PCs but also cloud-friendly devices, such as smart phones, PDAs, the mega-computers (supercomputers) enabled by virtualisation and software as a service. The data center of hardware and software is called cloud, which when made available to public is called 'public cloud'. Here, multiple clients can store their information in a single server and/or in the same data centre. On the other hand, the internal data center which is not accessible by public is called private cloud[4,13]. These are typically contracted by an organisation with a provider on one-on-one basis. Since, Private cloud is not shared with others, so it has higher level of security[7]. However, 'public Cloud' (also known as commercial cloud) and 'private Cloud' (also known as individual cloud) are already available from Amazon, Yahoo, Desktop Two, and Sun Secure Global Desktop, etc. However, Google's efforts in cloud computing have generated a great deal of interest[14,15].

4.1 Characteristics of Cloud Computing

There are many distinguishing features of cloud computing but some important features are[1,7].

(a) Versatility

(b) Cost-effectiveness (pay-per-use)

(c) Virtualisation

(d) Security

(e) Sustainability

(f) Scalability

(g) User-friendly

(h) Resource Optimisation

(i) Infrastructure and service-level agreements (SLAs)

5. ADVANTAGES OF CLOUD COMPUTING

From library perspective, cloud computing offers following advantages[1,16,17].

(i) There is no need to own all infrastructure facilities as cloud computing takes care of it.

(ii) Provides large amounts of processing power comparable to supercomputer level.

(iii) It can be used as a personal workspace.

(iv) Since the service is not location specific, it provides opportunity for ubiquitous computing.

(v) Virtualised technologies are a boon to green IT companies as virtual servers provide unlimited capacity, bandwidth, increased security and disaster recovery solution.

(vi) Capital expenditure is minimised.

(vii) It is far more economic, as payment is based on utilisation of service.

(viii) No need to copy all stuff from one PC to another when buying a new one. Moreover, one can create personalised repository of information that keeps growing as long as one wants.

(ix) A convenient tool to engage in the scholarship of teaching and learning.

6. CLOUD COMPUTING ARCHITECTURE

Cloud computing system can be divided into two sections-the front-end and the back-end which are connected to each other through internet. The front-end includes the client's computer and the applications required to access the cloud computing system. To explain further, the cloud computing system uses application programming interface (API) that enables machines to interact with cloud software in the same way as the user interface facilitate interaction between humans and computers[18]. There are various computers, servers and data storage at the back-end of the system that create the cloud of the computing services. A central server administrates the system, monitoring traffic and client demands to ensure that everything runs smoothly[6]. This follows a set of rules called protocols and uses a special kind of software called middleware.

7. COMPONENTS OF CLOUD

There are various components present in the computing space such as[4]:

(a) Infrastructure: The cloud infrastructure is a concept of providing the hardware as a service. The virtualisation technology allows servers and storage devices to be shared. Cloud computing relies on sharing of hardware and other computing resources, rather than having local servers, thereby reducing the cost of use and maintenance, etc.

(b) Storage: Separating data from processing and storing in a remote place is referred to as a cloud storage, which as a database, can hold large amount of data.

(c) Platform: A service for application deployment and managing the required hardware and software needs is known cloud platform.

(d) Application: In cloud computing the software architecture eliminates the need to install, run and maintain an application at the user's device, thereby, avoiding the cost/resource required to maintain or support applications.

(e) Service: An independent piece of software which can be used in conjunction with other services to achieve an interoperable machine-to-machine interaction over network is called cloud service.

(f) Client: Cloud client is a requester device (hardware or software) which tries to utilise cloud computing services over the network.

8. CLOUD COMPUTING AND LIBRARIES

Libraries have been in transition since their inception as they are directly affected with environmental changes. There was a time, when biggest library used to be the one with largest collection and they were serving their users mainly with their own resources in an almost isolated manner. Then came an era of computers where libraries started getting connected with other collaborating libraries through networks and consortia for mutual advantage of sharing the resources at divided/shared cost with a shift of emphasis from acquisition to access. Emergence of electronic resources has an added impact

on libraries which forced them to prepare to face different kinds of challenges from users to meet their multi-dimensional requirements. Now, there ia a new phase when libraries are adopting and utilising the computing resources and services that are not even owned by it. Cloud computing and Web collaboration are emerging as two major concepts, supporting innovative developments in library automation. Cloud computing is emerging to help libraries to offer much improved services by strengthening the power of cooperation among libraries and showing their combined presence on web. This will certainly help to enhance the efficiency of libraries by enabling them to access information through large global network of cooperating libraries and eliminating the IT-related problems, thereby saving time, money and manpower. With these developments, heterogeneous resources are accessible to anyone, anywhere because of the application of domain independent software.

Evidence of the library's active online or digital clients can be observed in the growing online social networks. In addition, forming of communities of interest among Web users indicate a growing movement toward Web collaboration which allows users without knowledge of the underlying internet's infrastructure, to create content and have a contribution to what is being communicated and published daily[8]. According to Farkas[19], it can be useful for libraries as web provides opportunities for libraries to collect the tacit knowledge (through knowledge management) that 'resides in people's heads' (collected through interviews/ personal documents) and benefit from the library's 'community of users' supplying 'feedback and contributions'.

Using cloud computing can share the server in many application procedures, realises the resource sharing, thus also reduced server's quantity, achieves the effect of reducing the cost. Therefore utilising cloud computing in the digital library, will give our work, the life and the study inevitably obtaining a greater efficiency[3].

Libraries traditionally manage servers with huge volumes of data and face critical problems in their management due to lack of expertise and the cost involvement in acquisition and maintenance of required hardware and software. For example the university or research libraries hold the data of thousands of electronic journal downloads and thousands of digitally converted data of rare/heritage documents. In any case there is a risk of data security and universal access. Therefore, the libraries can apply cloud computing to data integrity, upgrade and maintenance, intellectual property management, backups, disaster management, and failover functions. It facilitates reduced operational costs of IT resources; increases operational efficiency; extends distributed access through virtualised environment. By adopting this change, libraries can accrue increased reliability, declined costs due to economies of scale and other production factors. Many library staff members are already experienced users of cloud computing – without even knowing it. Some are using the cloud in the form of GoogleDocs. Staff users of Facebook take advantage of cloud, as do those who use photo sharing services such as Flickr[20]. Through Web 2.0 applications, the information seekers are shifting much of personal computer usage to the cloud. For example, bookmarks are freed from the desktop by storing them on social bookmarking websites such as Delicious, uploaded and shared videos on YouTube, used services such as slideshare to host presentations, some have designed applications for popular platforms such as Facebook. Under these circumstances, the LIS professionals have to catch up with the challenges of the IT savvy environment by utilising the applicability of following cloud computing service models in libraries:

(a) Software-as-a-Service (SaaS)

This is a software delivery model which remotely provides access through Internet to business functions as a service. In SaaS, a provider licenses an application to customers for use as a service on demand. SaaS software vendors may host the application on their own web servers or download the application for customers but it is disabled after use or after the demand contract expires. This type of cloud provides a wide range of applications (software) tools to end users. Any web application is a cloud application in the sense that it resides in the cloud. Google Docs (for word processing and spreadsheets), YouTube, SlideShare, Amazon, Facebook, Twitter, Flickr, and virtually every other Web 2.0 application is a cloud application in this sense. It offers several advantages like accessibility from any location, rapid scalability and bundled maintenance. Its applications in libraries are OpenURL resolver, journal listing service, instructional guides, reserves statistics, and IM/chat service. Its major limitations are threat to data security and oppose open source movement.

(b) Platform-as-a-Service (PaaS)

It offers platform on which software developers can build new applications or extend existing ones saving the cost of underlying hardware and software. This platform typically includes a database, middleware and development tools, all are in the form of services through the Internet. Its applications in libraries are integrated library system, archives management software, initial website applications, etc.

(c) Infrastructure-as-a-Service (IaaS)

This is another model of computing services and resources, also called utility computing. For this service, users are charged according to usage. This type of cloud provides virtual hardware capacity to organisations on an

elastic basis (flexible). Elasticity and scalability are the two terms associated with cloud computing that gives the ability to expand and reduce resources according to specific service requirement. Data Storage/hosting and archiving/preservation are important services among these. This system of packaging and storage requires minimum or no cost for hardware. Amazon was the pioneer in this, providing virtual machine instances, storage, and computation as innovative services. Amazon's Elastic Computer Cloud (EC2) is a major example of IaaS. Other examples include Rackspace's Mosso and GoGrid's ServePath, etc. IaaS provides servers, software, data-center space and network equipment, available in a single bundle. Its applications in libraries are for hosting institutional repository discovery layer, ILS discovery layer. However, Sanchati and Kulkarni[3] have also suggested some more service models which are as follows:

(d) Unified Search Service

Although majority of libraries are using OPAC (Online Public Access Catalog) but a uniform access platform is not available to share the OPACs. However, with the adoption of cloud computing, the integrated library resources support distributed uniform access interface, promote usage of library resources, answers users' questions by using high-quality navigation

(e) Real-time Access Services

Due to innumerable advantages of electronic resources, users prefer to access electronic journals and electronic databases. However, by introducing cloud computing, libraries can establish a shared public cloud jointly which can have infinite storage capacity and computing power bringing obvious benefits to libraries. It can help to reduce the substantial cost involved on purchase of electronic databases. Moreover, users can visit the shared resources by any terminal equipment, such as PC, mobile phone or PDA using internet access.

(f) Knowledge Service

In the context of knowledge economy, knowledge resources are directly affecting the productivity and national development. So the mode of dissemination of information and knowledge has become the most challenging task for librarians today. However, at this juncture, cloud computing and establishment of shared public cloud can help a great deal to save on manpower and resources. Moreover, with cloud computing, librarians won't have to maintain their own equipments or deal with users personally which will provide more time and energy to librarians to offer their users the needed information and knowledge-based services.

(g) All-people Service

With this model, libraries can provide services to all the people with the help of cloud computing. Anyone who can legally identity the network authentication has the right to visit the joint resources of libraries on the internet. There are some live examples of cloud computing for information management.

(i) OCLC Web Scale Management Services: It is from traditional ILS systems by offering member libraries one unified solution to help streamline routine tasks—like acquisitions and circulation. By moving these functions to the web, libraries are able to share infrastructure costs and resources, as well as collaborate in ways that free them from the restrictions of local hardware and software. With web-scale management services, the libraries will be able to:

- Lower total cost of ownership for management services;
- Eliminate format-specific operations;
- Simplify critical (but routine) back-office operations;
- Reduce the support costs for disparate systems;
- Customise and extend library management services by using new applications and services available from an open, extensible platform;
- Make your data (and libraries' aggregated data) work harder for better decisions; and
- Free staff time for high-priority services and local innovation.

(ii) LibLime—Hosted in LibLime's distributed cloud computing data center, hundreds of libraries are able to alleviate their internal IT support needs. No software is installed on desktops and no servers are required in the libraries[22].

(iii) Ex Libri—Ex Libris Group is a leading library automation solutions provider, offering the only comprehensive product suite for the discovery, management, and distribution of all materials—print, electronic, and digital[23].

9. CONCLUSIONS

With the unlimited growth of electronic resources and technological developments, libraries are facing the serious problem of budget constraints, which was never so acute earlier; moreover users' demands are multiplying and becoming more challenging. Under these circumstances, cloud computing which is a metered utility service like mobile or electricity, where users pay for real time use, is a great ray of hope. It is a broad array of web-based services, allowing users to obtain wide

range of technology-enabled services on a pay-as-you-go basis. As a result, it is becoming popular day by day because of its important features such as, cost-effectiveness, efficiency, user-friendliness, flexibility, data security, scalability, world wide connectivity and automatic adaptation, etc. So cloud computing is the broad concept of using the Internet to allow people to access technology-enabled payment based services that are greatly scalable and accessible from anywhere. The new trends in the automation spawned by recent web development are making libraries to be more reliant on software and computing resources provided by outside companies in service delivery to users. Therefore, in this environment, library should constantly attempt to improve user service models by adopting new technologies. Although the use of cloud computing is still in its infancy but effects of using it are quite obvious. With the introduction of Cloud Computing, libraries can certainly offer more effective and user-centric services.

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