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## THE PERSPECTIVES OF CLOUD TECHNOLOGY IMPLEMENTATION IN DIGITAL LIBRARY

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### Summary

The article examines general implementation opportunities of the cloud technology applications in the development of modern digital libraries. It studies the platform for digital libraries based on cloud technologies, their characteristics, and principles of development and use of information resources. Also considering registered data, personal information security and related issues in cloud based digital libraries. State-of-the-art in Azerbaijan, and the future application prospects of cloud technology in traditional and digital libraries was analyzed.

**Keywords:** cloud technology, cloud services, digital library, electronic catalogs, database, information resources, OCLC

### I. Introduction

Cloud technology is widely used in solving complex problems to develop distributed computing systems on the basis of computer networks. Such systems with large computational and memory resources are established on the basis of computer networks through high-speed communication channel. Using a high-speed communication channels makes it economically more profitable for the users of different organizations and institutions to take advantage of these cloud services. Thus, cloud technology is the communication technology with the help of which computing and memory resources of multiple computers (servers, computers, etc.) in large organizations are clustered and virtualized, and is the computing system, which provides data processing and storage for the users. Cloud technology ensures you to obtain powerful computing and memory resources, and at the same time, the user is not interested in the location and settings of these resources [1].

The use of Cloud technology in the development of digital libraries can be considered as a new stage, consecutively, it provides the creation of larger database, distribution of information over the network, ensuring the users new types of services, and reducing the expenditures.



First, it is important to analyze the main models and services of this technology, and its benefits in order to understand the application of cloud technology in digital libraries.

## II. Models and services of cloud technology

4 types of cloud technology are distinguished according to its definition [1,2,3]:

- Public clouds;
- Private clouds;
- Collective clouds;
- Hybrid clouds.

Public cloud - intended for public use. Subscriber of this cloud can be either company, or user. It offers solution of problems, which are impossible in other computing systems, at reasonable cost, and the development of web-sites or business-systems with measurement features. For example, Google Apps/Docs, Microsoft Office Web.

Private cloud - used and managed for only one organization. Everyone can use data, services and applications within the organization, but not outside of it.

Collective cloud - used and managed for only those organizations, which share common interests. Its structure can be distributed among one or more organizations, however, the essence is that required work is the same; the users require the same mission, strategy, security and speed.

Hybrid cloud – a model resulting from the combination and coordination of different cloud models (e.g., public, private and collective clouds). It is used by a number of internal and external cloud providers.

The following are the most commonly used technology in the cloud service models [1,2]:

**IaaS (Infrastructure-as-a-service).** A user has an access to operating system and applications of proper server (or servers). At the same time, he gets virtual server to solve the problem. IaaS allows you to lease the infrastructure (computing and storage system). The goal of the user is not to manage the structure, but to monitor the operating system, stored area, and established program. This service provides full access to artificial server to the customers. IaaS was first proposed by Amazon, currently two main products are used: EC2 (Elastic Compute Cloud) and S3 (Simple Storage Service).

**PaaS (Platform-as-a-service).** PaaS is a complex service, which includes the applications, database, testing programs and other developments. As a unique platform for the development of web-applications, their testing, deployment and maintenance, PaaS provides all operations in a single integrated environment, thereby, eliminates the costs spent to support various environments at different stages. E.g. IBM IT Factory, Google App Engine, Microsoft.NET Azure Services Platform (Windows Azure), Force.com, and so on.



**SaaS (Software-as-a-service).** The users are provided with software here. They are able to purchase the software via simple internet browser, and no local installations are needed. The software applications run in the provider's server, which offers SaaS service, and send the result of calculations to the user. Therefore, the user does not purchase the software, but uses it only when he needs to solve the problem, and pays proper amount of money for the use. For example, Microsoft "Software Services" (e-mail, video conferencing), Google Apps, Google Docs, and so on.

**Advantages of Cloud technology:**

- Reduced need of PCs connected to the Internet for computing and memory resources;
- Providing the users with unlimited computing and memory resources;
- Payment for actual use of computing and memory resources;
- High-speed processing;
- Reduced costs of hardware and software, service, and electricity;
- Ensuring physical security of data storage;

**Disadvantages of Cloud technology:**

- Stored data of a user depends on Cloud Computing service providers;
- Formation of new monopolists ("clouds");
- Reliability and security issues of communication channels;
- Methods and standards that ensure quality service in this field have not been developed;
- A user's computer must be connected to the Internet permanently;
- High speed communication channel should be provided;
- Impossibility of restoring lost data of a user in Cloud computing;

**III. Developing digital libraries with cloud technology**

If we look through technological capabilities of the middle of the previous century, we see that floppy discs were widely used in digital libraries as a space for data storage. However, it did not provide archiving large amounts of data. If we focus on recent years, we see that a lot of documents and data is digitalized and stored at "clouds" [4]. Currently, cloud technology is widely used in formation of digital library foundations, and in organization of services. One of the main objectives is acquisition of data and meta-data in the cloud-based holder, and automated management system must be developed in cloud environment. The data clustered through cloud-based information system is archived, and can be used for different operations. "The time of client/server has already passed by. We now live in a time of web-based cloud technology", Library Technology Guide web portal developer, Smart Libraries editor Marshall Breeding said about the use of cloud technology in the creation of cloud-based library systems [5].

As it is known, the rapid development of information technology in recent years has created a very different vision of information consumers 20-30 years ago. One of the key psychological features of this structure is that contemporary users are more



exacting, and passive to search for information, and impatient getting more information in a short period of time. Application of cloud technology in building work principle of an digital library allows the user to organize intelligent services in the boundless data "ocean", i.e., allows them to acquire the necessary information timely, with minimum efforts. Obviously, intelligent digital libraries include the data combining scientific and cultural aspects [6]. These databases do not require various computing procedures, as the equipment and software required for computing are not always available. In this case, cloud technology seems to be one of the most progressive ways to resolve these problems.

Modern intelligent electronic libraries are turning into large data processing centers. In this regard, these centers are computing systems, which provide acquisition of registration data (various documents, use data) and electronic documents, their processing, storage and use, by implementing clustering and virtualization of computing and memory resources of a large number of computers (working computers, servers, data centers etc.) located here [7].

Data resource processing issues cause the differences in cloud computing and traditional systems, and present a logical sequence. Two main directions should be considered in developing cloud-based intelligent digital libraries: 1. System purpose, and 2. Platform structure. Both directions are essential elements in the determination of the structure of the library, the user category, the formats of information resources and so on.

Another problem is that how the intelligent digital library use cloud technology. Logically, this process can in two forms, in the first case e-library uses the offers of cloud service providers, while in the second case, e-library offers cloud services itself.

If we take into account that, each organization and educational institution needs data centers in order to develop a digital library, and to store the data in databases. In its turn, their maintenance requires huge financial costs (using multiple operating systems, hiring groups of engineers and web-developers, energy use, etc.). To reduce above-mentioned financial costs, organizations and educational institutions have to store the data of digital library in unique cloud-based Data Centers [8].

Let's review the use of cloud technology models and services in electronic libraries.

If we take a glance at the specifications of cloud technology and digital libraries and combine them, we can see the same private, public and hybrid types here. E-library system is defined from the point of its type, commerce principle, and the types of resources. Private type means single digital library infrastructure with limited number of users regardless of profile. In this regard, it is responsible for purchasing virtual capacity and administrative expenses, which are intended for data processing and exchange. Digital library of collective type is applied by different users. These libraries need external investment sources outside of organization, including both



public and non-governmental organizations. Electronic libraries of hybrid type can be considered as a mixture of above mentioned two samples.

Above-mentioned may include e-library types such as academic repository, archive, media library, commercial database, and so on. Let's focus on, for example, internal working principle of private profit academic library. A folder called "Shared" is created at the central server in order to realize internal exchange of documents, and to work coordinately with different departments. An access to the documents in this folder is defined according to position of the employee, and to keep in contact with other departments. The documents collected in the folder may include the reports of separate departments, as well as the documents of various formats to share, and the data resources intended for users. If we focus more globally, we can see that most large companies, which offer a variety of services and use other services, realize all processes through cloud platforms with business interests. From this point of view, digital libraries should not only be intellectualized, but also be involved in commercial processes. Note that an digital library, as a global system, may deliver specific services to individual and corporate users itself. Particularly, it should be fully organized by interactive integration with CRM (Customer Relationship Management) technology.

SaaS, PaaS, IaaS services are widely used in formation of cloud-based digital library information system.

If we look up deeply, we can observe that SaaS platform is more applicable to integral library systems of different architecture (turnkey, hosted, stand-alone, SaaS/Cloud, open source, and so on.). As we noted above, let's analyze the first case, where a library or a company, as an e-library subscriber, uses from cloud services. A company, that delivers services over this platform, offers a part of "cloud" allocated for each client. The "clouds" proposed here may operate in a related form "corporately" or "individually" depending on the library type and relations, and so on. Cooperation of virtual information exchange with other libraries is also possible in this way. Most companies offer websites of their libraries. Sometimes this service is free of charge if other supplementary services are delivered. The data collected, processed and used here is backed up regularly, software and other technical issues are resolved, as well. In the second case, e-library services to the cloud itself. Most large companies engaged in library and information system widely use this technology. For example, if we look at working principle of OCLC (Online Computer Library Center), we can see that, collecting and processing global bibliographic records, the system offers services through a variety of online software and services (Connexion, Content DM and so on) in accordance with SaaS model [9]. The service allows any e-library not only to deploy its database on the company server online, and but also to use virtual automated management system of the company in order to control the data. PaaS platform is used here, as well. For example, one of the leaders in the field of library services 3M and Innovative



Interfaces companies offer the services to many libraries and museums, such as virtual server renting, data protection, software and adjustments, and so on [10]. From overall economic point of view, application directions of IaaS model is developing more rapidly in recent years; and many scientific e-databases (scientific digital libraries) provide information resources as the above-mentioned models. On the other hand, digital libraries use various cloud services themselves, and at the same time provide information resources such as, document collections of various formats, registration data, bibliographic databases, and so on, expanding its infrastructure for customers (users) [11]. For example, Proquest, Jstore, Ebsco Host, and so on.

One of the most important application problems of cloud technology is its difference from classic computer technology. Defining these diverse characteristics will present a new architecture of cloud-based e-library. Let's look through, for example, the implementation of the characteristics determined by NIST (National Institute of Standards and Technology) in digital library [12]:

*Automated self service* is an absolutely free use of cloud services. Note that, in this case, there is no need to apply to any additional administrators or network professionals. Compared to modern automated libraries, it reminds "open collection" format. In other words, a user can get e-library resource from the cloud and include it into his account through various equipments connected to the Internet without any intervention of library specialist. In cloud-based e-library the implementation principle of these processes not only in physical environment, but also from any geographic point online is put forward, of course, online use of information resources is a matter of priority here.

*Broad network access* defines the time, location and access of the user. Compared to the classical automated library, cloud-based library minimizes the solution. In other words, the consumer can use the offered services through any portable or desktop devices connected to the Internet from any location.

*Pooled resources* refer to a collection of resources collected from the network. The software does not need to be in the cloud, the main emphasis is a resource element here. For example, Greenstone program for the formation of an digital library. The option of folder selection, where the resource is downloaded, and "Dropbox" are available, as well. The program offers a virtual space free of charge for the deployment of the data of various formats, and if necessary, paid extra space.

*Scalability* is for the increase or decrease of usage measurement of the services offered by digital libraries and economic systems, software and so on, depending on the use of different resources.

*Metered service* provides the users with paid service. Cloud-based digital library can offer the user certain services as a virtual storage, resources and etc. as Dropbox and others.

Let's review the privacy issues of personal data in cloud-based electronic libraries:



The composition of the registration data collected in cloud-based electronic libraries consists of personal data. And the recent increase of such cases as cybercrime, unauthorized access to personal data, various data decoding, plagiarism and so on make it important to protect the personal data online. It should be taken into account, that these issues include the Article 12 of the UN's Declaration of Human Rights adopted in 1948, three years after the first scientific reasoning (UN web site). The rapid acquisition of scientific and technological innovations in the development information technology, transition of processing and use of personal data into virtual environment resulted in the adoption of the European Council Convention, № 108 for the "Protection of the Individuals with regard to Automatic Processing of Personal Data" signed on 28 January 1981 [13].

Personal information is any fact, comment and knowledge about any event, activity and situation associated with the person's life and family, which ensures the person's direct or indirect identification. Above mentioned set of data may include the set of social and legal, physiological psychological and other information related to separate individuals. In modern times, more sensitive approach exists to this issue; especially when portable devices and mobile communication develops rapidly, the population is aware of maintaining the personal data confidential from early ages at kindergartens, schools, mass media, libraries, and so on. However, the state regulates the data sets of personal information depending on its use, privacy and publicity according to the state's legislation.

Organizing the use of personal data in the cloud-based electronic libraries during intelligent e-services is one of the most important structural elements. It includes behavioral issues of the personnel (librarians and information specialists, IT specialists etc.) and individual users and a group of users in regard to private information. Note that, actually, one of the elements definitely included into the theoretical concept of "new generation digital library" is high level organization of security issues of the perfect management system. If we take into account that after 9/11 attacks, the European Union countries decided to store the users' records in the Internet log-files by the providers (ISP) for 18 months [13]. In this case, in general, the absence of time-limits of personal data storage in cloud-based electronic libraries prioritizes focusing on security issues.

Before the structural principles of electronic libraries, let's take a look at the process of use and processing of the personal data of the users stored in two integrated library systems of classical model as 1. Millennium ILS (USA) and 2. Irbis64 ILS (Russian Federation) systems from various aspects. Though, both systems are provided with "Circulation and access" module to work with the users, the main difference is saving or deleting the usage history of retrieved resource in the system. The first usage history is not stored, however, it should be noted that in the second case, the list is saved and can be canceled by the user himself. The Code of Ethics of American Library association writes "We respect the privacy and confidentiality of



information needs, claims, requests and consultations, acquired and transferred data of the library users, and protect their rights [14].

Another issue is that, the user can't get the resource if it is currently used by another user, and the user is only informed about the time, when the resource is back. Note that the transmission of the information by the librarians and information specialists, who organize the work with the users, may cause a number of negative domestic, social and psychological problems. Another side of this process is that special state agencies may benefit from the library data against crime, and counter-intelligence issues. For example, in 1980s, FBI (Federal Bureau of Investigation) launched "Library Awareness Program", which in case of necessary incidents libraries provided information about library users' data, their needs, reading habits, and so on [15].

Cloud-based e-libraries handle the principle of operation of personal data more sensitively, and to represent an ideology of a new kind of individual electronic libraries. This looks like a working room of thinkers, scientists and other intellectuals. This type of electronic libraries may consist of virtual offices (separated cloud parts) of any quantity, and the personal data may be used accordance with appropriate principles depending on the will of each person. In other words, if the user requires keeping the use of resources, active hours, and personal data confidential from other individual users or user groups, it must be definitely provided within the legislation. Stating from these citations and ideas, it should be noted that, the main objective of developing cloud-based e-library is to provide intelligent information environment ensuring maximum security, comfort and dynamics of the users, preventing time and location problems [16].

As many technological factors, above mentioned technological opportunities have advantages and disadvantages. As the research topic is related to the library environment, let's review application opportunities of cloud technology in the traditional automated and digital library structures of the Republic of Azerbaijan.

The advantages of introducing cloud technology in an digital library system:

**General technical features** - At present, most libraries of Azerbaijan purchase Integrated Library Systems, d-library Management Systems, or get them free of charge, and need to realize operations, such as staffing, system configuration, as well as the purchase of server equipments, allocation of physical space, additional server room cooling, technical applications, and etc. So many companies are now performing proper services taking into account technical specifications mentioned in all three service models (SaaS, PaaS, IaaS) basis, and reducing additional costs. For example, if the central library, as well as its branches purchase the software (Integrated Library System or Digital library Management System) on the SaaS model, in this case, allocation of additional server, system configuration, extra use of electricity, and the procedures such as involving additional personnel will not be needed. Note that this process can be solved within the framework of cooperation of





several centralized library systems. As a result of this process, cooperative, as well as independent cloud network will be formed [17].

**Online work principle** - work principle of electronic libraries with several currently allocated data centers, and 24/7 database support system is usually limited. It means that, the power outage, the network degradation, hardware failure may lead to serious irregularities in the organization of the service. Taking into account the processes, the main functional specifications of the companies, which offer cloud services, include technical processes, such as duplicating and data “mirroring”. For example, for security purposes, “mirrored” copy of the bibliographic data of the library is stored in the central servers of the company [17, 18].

**Access and use** - classical computer principle requires the users to be in the same network, or complex virtual private networks (VPN) to be configured. And the opportunities of cloud technology ensure the users to access the needed information from different platforms via the Internet from any geographical location, overcoming beyond the physical barriers. For example, due to legal and technical process, the local library system in the country has not configured yet, however, in practice, subscribing foreign digital library systems, the users access the resources needed for them from any location anytime via own accounts.

The disadvantages of introducing cloud technology in an digital library system:

**General safety and confidence** – Each technical innovation reminds some kind of “aspirin” effect. Thus, each technical solution, of course, has its shortcomings. The most sensitive part of the cloud is the data security and confidence. Compared to other companies, which offer information services, the companies, which perform such cloud services, are more responsible, requiring the technical processes, such as greater number of data acquisition, data processing and transmission.

**Personal information management** - Another matter is the personal data protection, unauthorized access, identifying the data usage, including data access. Note that, personal data is one of the most important elements in data security.

**Maintenance** – Note that, the disadvantage of this element may cause serious problems in information supply. In this process, the user and vendor collaboration, signed a memorandum of understanding, and the contract is of great importance. If the main data resources, software, and other related elements of digital library are organized through the cloud services, and if there is a problem with the maintenance, in this case, the service may be completely stopped, or continued on limited or in temporal basis, or some services may be stopped dependently on service agreement. This is particularly relevant to the local libraries. Thus, due the financial problems, the e-libraries or various scientific bases are not used or remain inactive [17, 18].

#### **IV. The prospects of applying cloud-based e-libraries in Azerbaijan**

**Virtual space:** With cloud technology provides both classic automated libraries and electronic libraries to have an access to a wide range of capacity of the virtual space. Note that, involvement of not only the libraries, but also archives, museums and



other enterprises is inevitable. For example, one of the problematic issues of many academic libraries of the republic is the problem of virtual space (allocated server). However, the new technical possibilities will be able to overcome this problem with the most optimal terms. A few libraries or e-libraries may benefit from cloud space both individually and corporately, by mutual agreement with favorable terms.

**Cooperation and individuality:** The principle of virtual collaboration is supported in the implementation of major projects, information exchange, and database structuring. As a result of a joint action, this idea reflects the formation of large-scale, systematic, clustered e-libraries and offering their services to multi-category users. Each user has an access to the huge wealth of virtual library from his personal cloud. If we take a look at the local situation, certain difficulties are observed in the decentralization and collaboration, which results in time and effort waste. Many attempts have been made in library information system, but these projects did not fully operate. This technology defines formation of cost-effective d-library networks of both financially and organizational quality.

**Security:** In modern times, one of the most important issues is to ensure database security. Cloud can be regarded as one of the best technology for the protection of large-scale collection of e-library resources [16]. Compared to the library and information infrastructure applied in Azerbaijan, this perspective can overcome many traditional and manual method of cataloging, and some principles of copying.

At present, a number of scientific, commercial and other enterprises of the republic offer cloud services. For example, Data Center of AzScienceNet, Institute of Information Technology of ANAS is providing computing and memory resources. As well as, a lot of organizational work has been done for the file achieving of the institutions of ANAS. Apparently, resource base and functionality is extensive, which emerges certain administrative, technical requirements and specifications. As key element, above mentioned procedures are forms of the proper distribution and efficient use of resources [2].

In terms of the introduction of the given processes in the digital library, a new Information Resource Center was established under the Azerbaijan National Academy of Sciences. In the future, hybrid e-library functions are planned to be applied in this library model, which is equipped with modern technology. Note that, is one of the priorities of the center is the development of "Azerbaijan Digital Memory" e-library. In a broader look, digitalization, archiving and exploitation of all resources obtained from all major libraries, archives, and other related individuals at the national level, is expected to be available within the legal guidelines. If we analyze all of these facts, take into account the future prospects, we will observe that the application of cloud technology in the mentioned center is not only needed, but also very important.

There are many institutions, academic institutions, libraries, institutes of manuscripts, which store valuable collection of documents expressing science, culture, and history



of Azerbaijan in the traditional database. Cloud technology, which is the subject of the research, provides more effective, low-cost and quality data collection, processing and protection.

#### V. Conclusion

In presented article were analyzed the models and services of cloud technology, which are very important for the creation of modern digital library information systems. With the technical capabilities of this technology it is possible to obtain resources from the libraries, museums, archives and related organizations for the purposes of centralized processing, archiving, preserving and organizing public, individual, special access, taking into account the juridical issues. The paper also analyzes formation principles of more effective, efficient, fast and low-cost resource management possibilities. At the same time, it explores advantages and disadvantages of cloud-based e-library systems which is very important for future researches.

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