

DIGITAL ERA: UTILIZE OF CLOUD COMPUTING TECHNOLOGY IN DIGITAL LIBRARY

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Abstract

With the purpose of applying cloud computing to digital library, the paper initially describes cloud computing and analyzes current status of cloud computing in digital library. Then it proposes the architecture of cloud computing in digital library and summarises the application of cloud computing in digital library. Finally the author brings out the future improvement in digital library using cloud computing technology.

Keywords: Information resources, Digital Library, Server.

INTRODUCTION

Within the past decade the number and kinds of digital library information sources have proliferated. Computing system advances and the continuing networking and communication revolution have resulted in a remarkable expansion in the ability to generate process and disseminate digital information. Together, these developments have made new forms of knowledge¹ repositories and information delivery mechanisms feasible and economical.

Digital library, as we all know, is famous for its academic and technical influences. And IT technology has been the driving force of library development. What's more, librarians can keep using new technology to develop digital library and optimize library service. With the expansion of Cloud Computing application, this paper proposed to apply Cloud Computing in digital libraries. By establishing a public cloud among many digital libraries, it not only can conserve library resources but also can improve its user satisfaction.

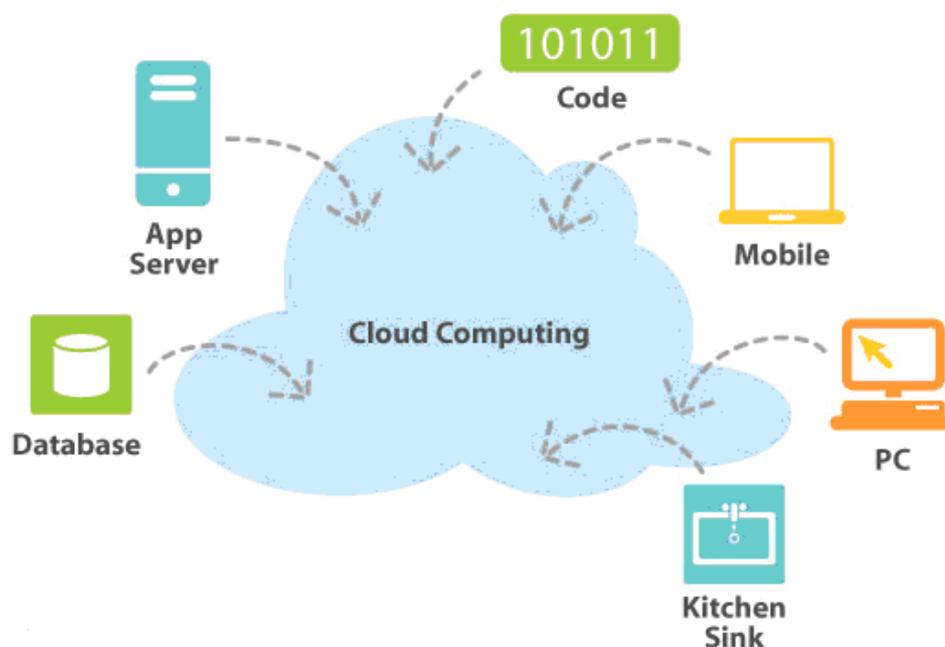
Cloud Computing is a completely new Information Technology and it is known as the third revolution after PC and Internet in IT. As it is still an

evolving paradigm, its definitions, use cases, underlying technologies, issues, risks, and benefits will be refined in a spirited debate by the public and private sectors. According to the definition of NIST (National Institute of Standards and Technology), Cloud Computing is a model for enabling convenient, on-demand network access to a shared pool of configurable computing resources (e.g., networks, servers, storage, applications, and services) that can be rapidly provisioned and released with minimal management effort or service provider interaction. To be more specific, Cloud Computing is the improvement of Distributed Computing, Parallel Computing, Grid Computing² and Distributed Databases.

What is Cloud Computing

“A Cloud is a type of parallel and distributed system consisting of a collection of inter-connected and virtualized computers that are dynamically provisioned and presented as one or more unified computing resource(s) based on service-level agreements established through negotiation³ between the service provider and consumers.” Figure1 denote resources of cloud computing.

Figure1: Resources of Cloud Computing Technology



Cloud computing seems to offer some incredible benefits for communicators: the availability of an incredible array of software applications, access to lightning-quick processing power, unlimited storage⁴, and the ability to easily share and process information. All of this is available through your browser any time you can access the Internet. It means computing ability also can be a kind of commodity, as gas, water and electric, easy to use and cheap cost. “Cloud Computing” brings such a change – “computer storage computing center” are set up by professional network companies such as Google and IBM, through one cable and user can access easily with browser, make “Cloud” as the center of material storage and application services.

Definition

Cloud Computing is associated with a new paradigm for the provision of computing infrastructure. This paradigm shifts the location of this infrastructure to the network to reduce the costs associated with the management⁵ of hardware and software resources. The Cloud is drawing the attention from the Information and Communication Technology (ICT) community.

“The key concept behind the Cloud⁶ is Web application... a more developed and reliable Cloud. Many find it’s now cheaper to migrate to the Web Cloud than invest in their own server farm ... it is a desktop for people without a computer”.

R. Bragg (2008)

Need for Cloud Computing in Digital Libraries

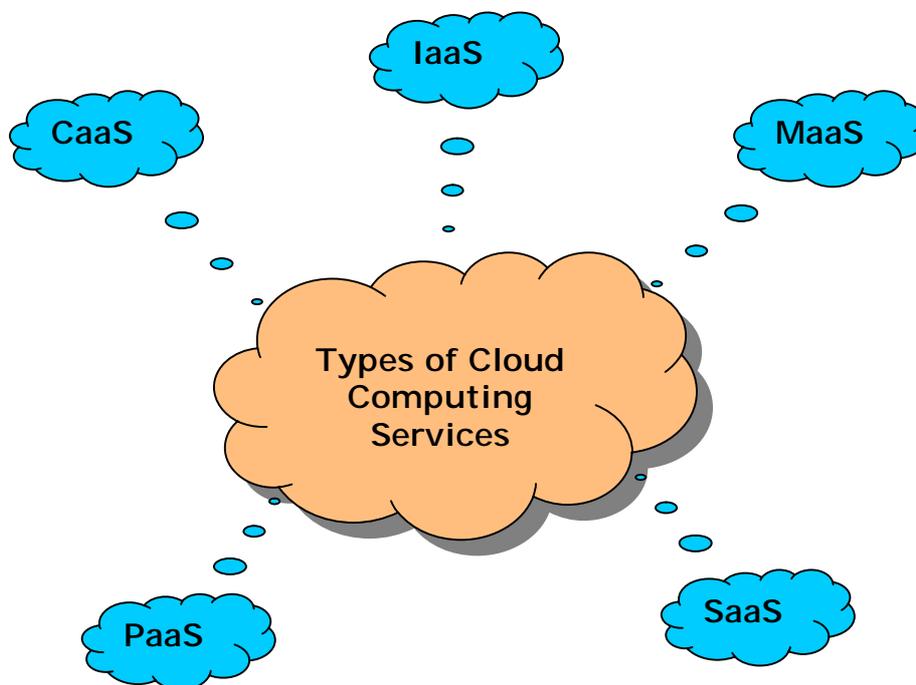
Digital library, as a most important academic and scientific research base, charges for providing information services for its users. In the past, most libraries insisted that their service is based on their own library resources. So librarians scarcely considered users' demands. But today, digital libraries have changed this viewpoint. And librarians usually need to collect as more information as they can according to users' requirements. Then they will analyze

the information and sort out them. Finally, they will provide them for users in some certain technical methods. However, services in digital libraries will increasingly focus on users' demanding in future. And the ultimate goal of digital library is to offer appropriate, comprehensive and multi-level services for its users. With the introduction of Cloud Computing⁷ to digital library, services of libraries will have a new leap in the near future. Services provided by digital libraries will become more user-centric, more professional and more effective, etc. And we all believe that digital libraries will create more knowledge benefits for our country with the help of Cloud Computing.

The State of Cloud Computing in Digital Library

Cloud platforms enable organizations to use external expertise and resources to deliver complex services, remove the need for organizations to invest in server infrastructure, and lower the cost for organizations seeking elastic computing resources. Libraries have been adopting cloud-based solutions for different services including electronic journal access management, statistics tracking, digital library hosting, and even integrated library system (ILS) hosting. This has allowed libraries to make strategic choices about the allocation of resources and to offer better service than would be possible if relying on in-house solutions. While much of the focus on cloud computing in digital libraries has been on subscription service or platform (e.g. ILS hosting). There are cases where digital libraries need computing resources for requirements that are not provided by service or platform providers. Cloud computing can be divided into five categories: Communication-as-a-Service (CaaS), Infrastructure-as-a-Service (IaaS), Monitoring-as-a-Service (MaaS), Platform-as-a-Service (PaaS), and Software-as-a-Service (SaaS). Figure 2 represented below depict the types of cloud computing services and its related features.

Figure2: Types of Cloud Computing Services



- **Communication as a Service (CaaS):** Allow for certain messaging⁸ tools viz voice over IP (VOIP), Instant Messages (IM) and Video Conferencing.
- **Information as a Service (IaaS):** Allows customer to maintain owner and management of their application while off-loading infrastructure management⁹ to the IaaS provider.
- **Monitoring as a Service (MaaS):** Outsourcing of security service¹⁰ to a third party security team.
- **Platform as a Service (PaaS):** Meant for web-based¹¹ development infrastructure.
- **Software as a Service(SaaS):**When a software vendor supplies software¹² over a network as opposed to the typical distribution of installation of individual computers

Digital libraries have quietly been on the forefront of cloud computing technology for a number of years. The use of SaaS in digital libraries reaches back into early 2000 with the establishment of companies like Serials Solutions¹³. Much of the work is migrating to electronic journals and it has focused on a SaaS platform, and recent companies¹⁴ such as Lib Guides have

shown that libraries are willing to invest in SaaS solutions. In the IaaS arena, Amazon Elastic Computing Cloud (EC2) offers IT infrastructure for organizations to launch different sized servers using a variety of operating systems, including several flavors of Linux and Windows. EC2 provides organizations with essentially unlimited storage using their S3 service, the ability to take snapshots of both data and servers, and the ability to include EC2 servers in an organization's private¹⁵ network.

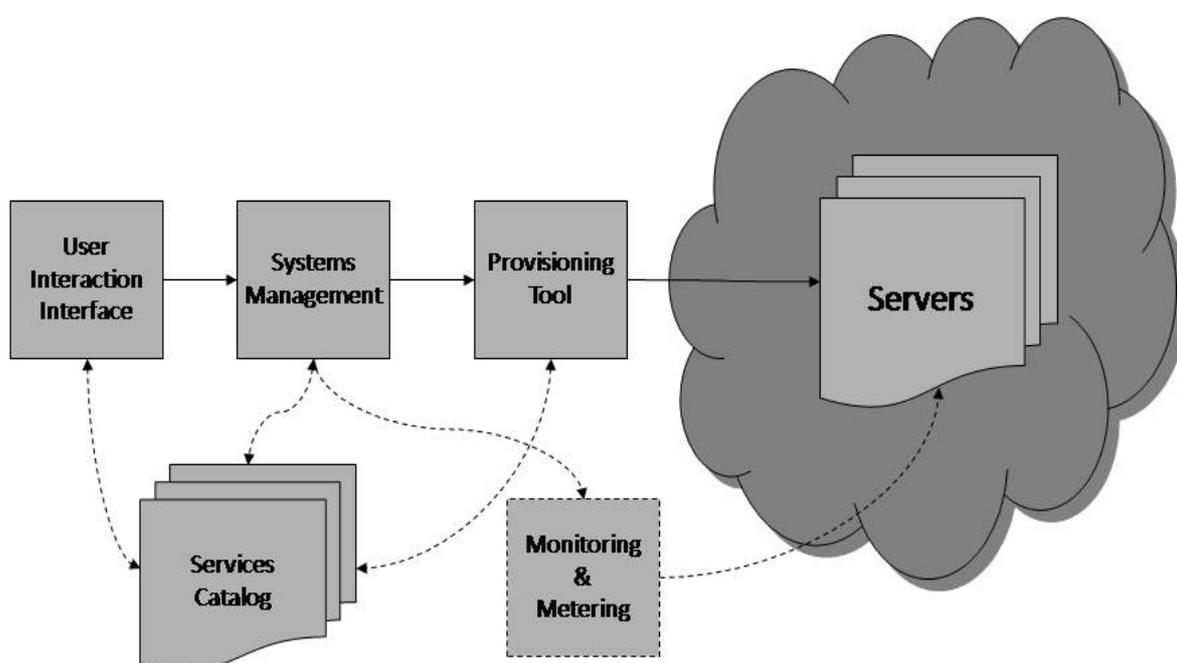
Wheeler and Waggener (2009) use this classification¹⁶ (SaaS, PaaS, and IaaS) as a launching pad to discuss ways in which they can be used to enable collaboration or 'sourcing' between institutions and consortia. Marshall Breeding (2009) places these three types of services¹⁷ within the context of other infrastructure and hosting options such as co-location (the duplication of specific IT resources in multiple places), shared and dedicated hosting (licensing a shared or distinct portion of a server for use), and cloud computing (abstracting the hardware, software, and service layers to provide an extensible computing environment). Embedded within these classifications are needs and use arguments, organizational goals, and institutional priorities. Digital libraries are in a unique position to experiment with cloud computing given their service-oriented mission and need to find appropriate solutions using limited resources. Fox (2009) observes that the goals of the organization¹⁸ have an impact on their use of cloud solutions (2009). Digital Libraries are often supported by external or organization level IT services and do not have internal expertise on advanced IT management. Many libraries have been active in investigating innovative uses of cloud computing (Kroski, 2009), including new ways of using infrastructure¹⁹ services. Kroski's article mentions the use of Amazon EC2 services by both the DC Public Library system and Ohio Link to provide library IT services using IaaS techniques.

Both the Gartner Hype report²⁰ on cloud computing (2009) and the Educause Horizon report²¹ (2009) point to the expansion of cloud services in the coming years. Digital libraries and especially academic organizations have largely followed suit, having already migrated key services such as Open URL providers, and federated and pre-indexed search engines.

Architecture of Cloud Computing in Digital Library

The architecture²² behind cloud computing is a massive network of "cloud servers" interconnected as if in a grid running in parallel, sometimes using the technique of virtualization to maximize computing power per server. The following figure 3 represents the architecture of cloud computing in digital library.

Figure3: Cloud Computing Architecture for Digital Library



A front-end interface allows a user to select a service from a catalogue. This request gets passed to the system management which finds the correct resources, and then calls the provisioning services which carves out resources in the cloud. The provisioning service may deploy the requested stack or web application as well.

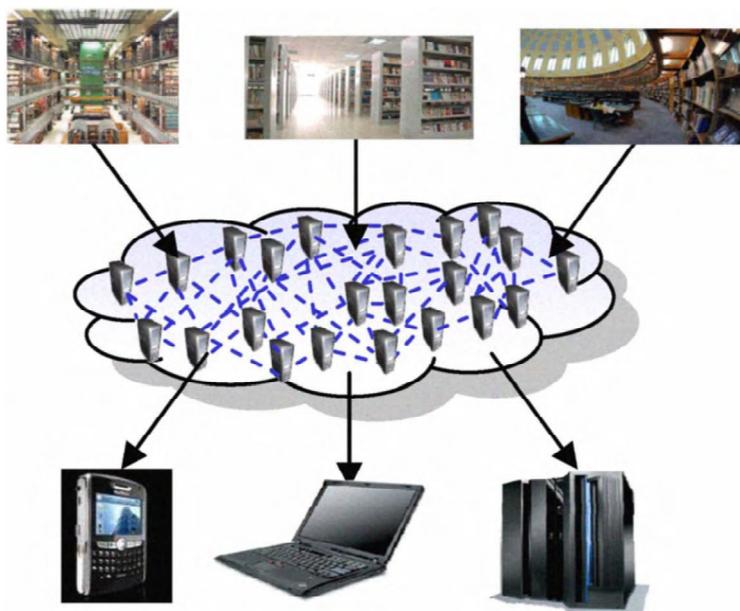
- **User interaction interface:** This is how users of the cloud interface with the cloud to request services.
- **Services catalogue:** This is the list of services that a user can request.
- **System management:** This is the piece which manages the computer resources available.

- **Provisioning tool:** This tool carves out the systems from the cloud to deliver on the requested service. It may also deploy the required images.
- **Monitoring and metering:** This optional piece tracks the usage of the cloud so the resources used can be attributed to a certain user.
- **Servers:** The servers are managed by the system management tool. They can be either virtual or real.

Application of Cloud Computing in Digital Library

Digital library is a development-oriented hardware and software integration platform, through technical and the product integration. Each kind of carrier digitization carries on the effective deposit and the organization provides the network with effective service. Figure 4 illustrates application of cloud computing in digital library.

Figure4: Application of cloud computing in digital library



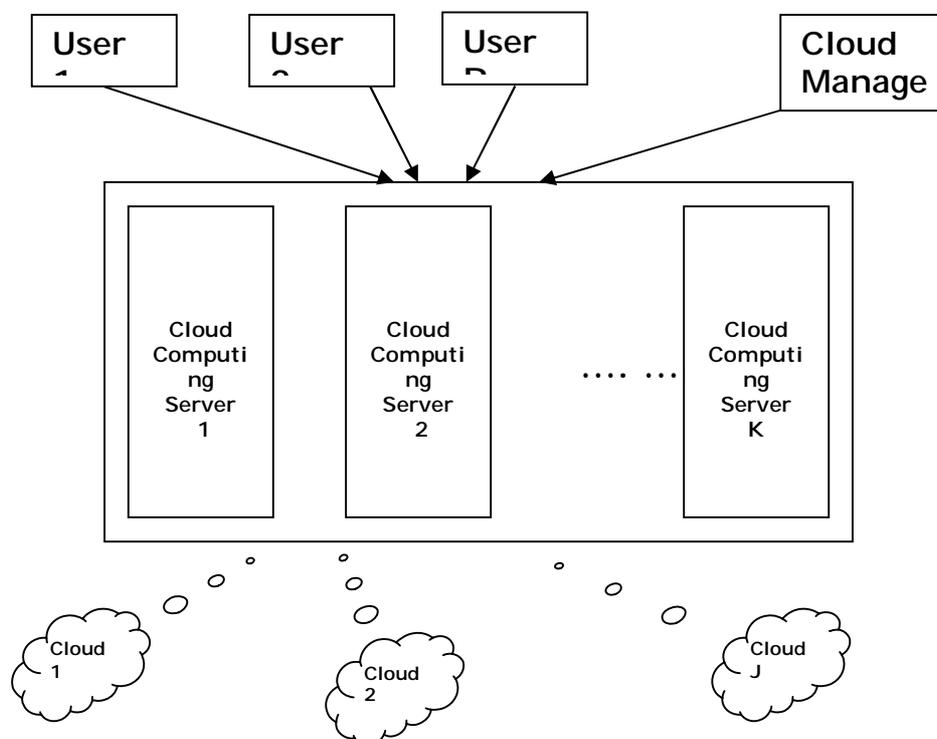
Cloud computing offers real alternatives to Information Technology field for improved flexibility and lower cost. Digital Libraries²³ are developing for software applications, platforms, and infrastructure as a service to Information Technology departments over the “cloud”. It also provides for better and easier management of data security, since all the data is located on a central server, so

administrators can control who has and doesn't have access to the files. The main objective of cloud computing is to use a specific software through calculation and the data stored in a desired computer distribution which causes the enterprise to reduce cost and improve performance. Digital library represents one kind of new infrastructure and the environment; through cloud computing technology since it uses resources more effectively and can solve the constraints in digital library.

Cloud Computing Recognition Permissions Apprehension

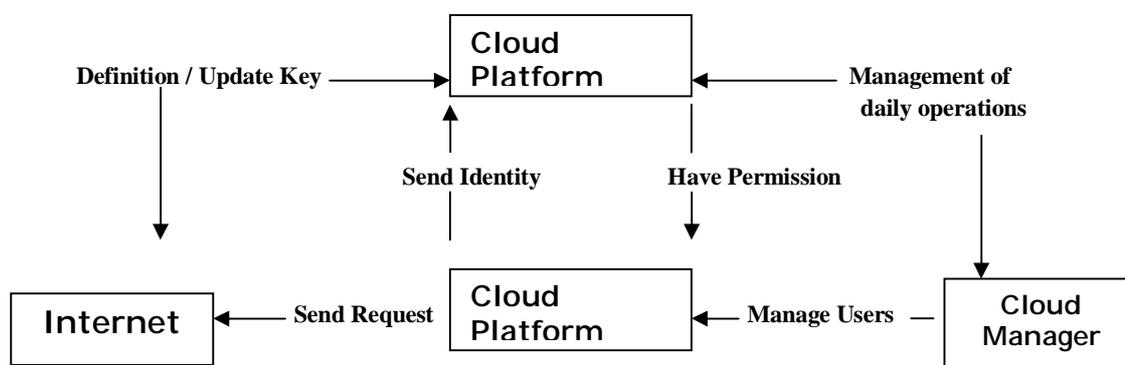
- I. Cloud Computing Recognition:** Using cloud computing technology, one can share the server in many application procedures, realize the resource sharing thus reduce server's quantity, minimize the cost. Therefore implementation of cloud computing technology in digital library will promote user's work and study to get done with a greater efficiency. Every cloud computing server may function alike computer server and save the server or the broad band resources and so on. Figure 5 represents implementation of cloud computing technology in digital library where every cloud represents any digital library database resource, every two clouds or more clouds may compose a bigger cloud and might divide the cloud or network of clouds by different section.

Figure5: Implementation of Cloud Computing Technology in Digital Library



A SaaS and PaaS service typically includes a database, middleware and developmental tools, which are all in the form of services through the internet, which facilitate the users and suppliers to reduce cost. IaaS provide servers, storage and networking hardware. SDK, Software Development Kit, refers to supporting development of a specific software, documentation, samples and collection of tools. In general SDK is used under windows platform.

II. Permission Apprehension: Cloud environment is a highly developed network environment; it appears to the users of high-quality service and high security. The Cloud computing techniques and methods applied to digital libraries, not only can improve the utilization rate of resources to address the imbalance in development between regions, but also can make more extensive use of cloud computing to our work life. Figure 6 denotes permission apprehension of cloud computing in digital library.

Figure6: Permission Apprehension of Cloud Computing in Digital Library

Initially user is requested to internet transmission, and between the cloud platform and continuous Internet revision key, in order to protect the platform. Simultaneously the cloud platform defines an access rule to its users and the user transmits their own status to the platform and the platform grants the user specifically for the permissions statement.

Future Improvements in Digital Library Using Cloud Computing Technology

In an era of shrinking budgets, it gets harder with each passing year to justify the purchase and maintenance of servers that aren't in use almost all the time. Cloud computing²⁴ offers price savings due to economies of scale and the fact that you're only paying for the resources you actually use. Organizations of all sizes can take more risks when it comes to creative, innovative technology ideas when the new application will run on someone else's infrastructure. Digital libraries do not have to decide between devoting their limited server resources to the OPAC's overflow traffic and a new mobile web application that one of your colleagues wants to develop. If they're both hosted in the cloud, the resources devoted to each will shrink and expand as traffic rises and drops. Furthermore, creating and configuring new virtual server instances is fast and easy in the cloud.

Digital libraries may soon be building and managing their own data centers. In addition to all the hype and optimism surrounding cloud computing, there are still significant fears and doubts Industry Challenges points out. In particular, the major cloud computing vendors haven't yet fully addressed concerns about

security, privacy and reliability. These concerns are leading some companies to build their own private or hybrid clouds. A hybrid cloud²⁵ is primarily based in a privately-owned and operated data center, but it can shift some of its traffic and data processing requests to public cloud vendors such as Amazon or Rack space on an as needed basis. This hybrid model would let digital libraries maintain more control over the applications and data stores that contain sensitive, private information about patrons. Moreover, digital libraries can continually adjust and fine-tune the balance between the tight control of a private Information Technology infrastructure, and the flexibility and savings of cloud-hosted infrastructure. Just as digital libraries presently cooperate with one another to buy Information Technology equipment, bandwidth and the services of Information Technology professionals, Digital libraries may soon cooperate in the building and management of data centers. Alternately, if enough digital libraries express interest, a company such as Google, Amazon, Microsoft or another cloud vendor might create a digital library Cloud similar to Google's Government Cloud. Or, a library vendor with deep Information Technology resources (e.g. OCLC or Sirsi Dynix) might build digital library-centric cloud services on top of cloud infrastructure leased from one of the more established players.

CONCLUSION

Cloud computing represents an exciting opportunity to bring on-demand applications to Digital Library, in an environment of reduced risk and enhanced reliability. However, it is important to understand that existing applications cannot just be unleashed on the cloud as is. Careful attention to design will help ensure a successful deployment. Certainly cloud computing can bring about strategic, transformation and even revolutionary benefits fundamental to digital libraries. For organizations providing digital libraries with significant investment in traditional software and hardware infrastructure, migration to the cloud will bring out considerable technology transition; for less-constrained organizations or those with infrastructure nearing end-of-life, adaptation of cloud computing technology may be more immediate.

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