

JOURNAL OF LIBRARY SCIENCE IN CHINA

Volume 8, 2016

中国图书馆学报

图书在版编目 (CIP) 数据

中国图书馆学报年刊 (英文版) : 2016 / 中国图书馆学报编辑部编. — 北京 : 国家图书馆出版社, 2017.2

ISBN 978-7-5013-6040-6

I. ①中… II. ①中… III. ①图书馆学—中国—2016—年刊—英文 IV. ①G250-54

中国版本图书馆CIP数据核字 (2017) 第022326号

书名 中国图书馆学报年刊 (英文版) : 2016

著者 中国图书馆学报编辑部 编

出版 国家图书馆出版社 (100034 北京西城区文津街7号)

发行 010 - 66139745 66151313 66175620 66126153

66174391 (传真) 66126156 (门市部)

E-mail btsfxb@nlc.cn (邮购)

Website www.nlcpress.com

经销 新华书店

印刷 北京科信印刷有限公司

开本 787 × 1092毫米 1/16

印张 14.75

版次 2017年2月第1版 2017年2月第1次印刷

书号 ISBN 978-7-5013-6040-6

定价 RMB 80 (中国) ; USD 110 (国际)

Journal of Library Science in China

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Published by: National Library of China & Library Society of China, No.33 Zhongguancun Nandajie, Haidian District, Beijing 100081, China
Edited by: Editorial Office of *Journal of Library Science in China*, No.33 Zhongguancun Nandajie, Haidian District, Beijing 100081, China
Tel: (+86 10) 88545234 or (+86 10) 88545141 E-mail: jlis.cn@nlc.cn http://www.jlis.cn
Printed by: Beijing KEXIN Printing Co., Ltd., Beijing 100192, China Tel: (+86 10) 62908529 Fax: (+86 10) 62991269
Distributed by: National Library of China Publishing House, No.7 Wenjin Street, Beijing 100034, China.
Tel: (+86 10) 66139745 Fax: (+86 10) 66174391 E-mail: btsfxb@nlc.cn http://www.nlcpress.com
Subscription: RMB 80 (China) / USD 110 (International)

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Published February 2017

Beijing, China

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Opportunities and challenges faced by digital libraries in the big data era^①

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Abstract

Construction of network-based academic resources is undergoing rapid development in this big data era, displaying a trend to replace digital libraries. This challenge calls for the construction of digital libraries to have big data related considerations, i.e., from resource construction aspect, we should expand the resource scope, aggrandize the breadth of resource integration, and increase the depth of the resource organization and processing; from technology application aspect, we should attach great importance to the semantic technology, emphasize the application of clustering technology, widely adopt data analysis technology, and elevate the retrieval technology level; from service aspect, we need to enrich services and product categories of digital libraries, and convert the passive, and general service mode to the proactive and personalized mode. The construction of next generation digital libraries must differ from the traditional way. Comprehensive service ideas should be established; comprehensive resource services should be provided; the conventional service mode and transmission form also need to be expanded; even the librarians of digital libraries are required to become data analysts.

Keywords

Big data, Digital libraries, Resource development, Service concepts, Service mode

0 Introduction

The debate between Ma Yun and Wang Jianlin about the topic “whether e-commerce can replace traditional entity based retail industry in the next few years” in Dec. 2012 did not come to a final conclusion. The fact was that on Nov.11, 2014 alone, the gross sale of Alibaba’s Tmall taobao reached more than 50 billion yuan, which has motivated us to rethink the topic whether e-commerce can replace traditional business in the next few years. It has also caused another anxiety: whether the traditional digital library will be replaced by the construction of emerging network resources in this big data era. Now the question is neither an alarm nor a lie, but has become real.

At present, the construction of academic resources is booming. China National Knowledge

^① This article is an outcome of the project “Knowledge Service Oriented Knowledge Organization Model and Application Research” (No.71273126) supported by National Natural Science Foundation of China.

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Infrastructure (CNKI) as the largest constructor of academic resources in China, for example, has expanded its business from domestic journals to domestic and overseas journals, conference proceedings, dissertations, important newspaper articles, patents, standards, and so on. From book resource aspect, it has collected a large number of books, provided query service of yearbooks and reference books, and set up a teaching aid platform recently (“China National Knowledge Infrastructure”, 2015). Another important academic resources service provider – Wanfang Data Knowledge Service Platform (“Wanfang Data Knowledge Service Platform”, 2015), also provides academic resources such as domestic journals, dissertations, conference proceedings, patents, standards, local chronicles, laws and regulations, science and technology achievements, books, industry organizations, experts, and scholars. There are other resource constructors like VIP Journal Integration Platform (VJIP) having great achievements in academic resource constructions. Currently these resource constructors hold more non-book resources than most libraries in China. And most of the university libraries in China even have to rely on the academic resource services provided by these resource constructors.

A “Superstar Digital Library” mainly providing book services was constructed by Beijing Century Superstar Information Technology Development co., LTD. The digital library contains over 50 categories such as literature, economy, computer and so on, millions of electronic books, over 5 million academic articles with the full text in extent of 1.3 billion pages (“Superstar Digital Library”, 2015), and has reached the book collection scale of a large library. Someday it will exceed the quantity of book collections of the majority of libraries in China. In addition, this digital library has collected approximately 200,000 sets of academic videos (“Superstar Digital Library”, 2015), which has a big impact on the traditional digital libraries in China.

In the construction of literature resources, in addition to the above academic resource constructors, some network resource providers also have joined. For example, Baidu has entered the field of academic resources (“Baidu”, 2015). It offers Baidu library, Baidu encyclopedia, as well as hundreds of thousands of books. The Baidu scholar search launched in 2014 even provides the academic information which cannot be obtained from the traditional digital libraries. Baidu scholar search is a one-stop academic resource search platform which provides large amounts of English or Chinese, paid or free literature for retrieval, and has become a perfect assistant in academic research. The amount of information currently possessed by Baidu is estimated to be more than 1,000 PB, equivalent to 50,000 times of the amount of digitized data in the National Library. The daily increment is estimated to be 10 TB, equivalent to half of the digitized data in the National Library (“Industry Data Quantity of China in 2013”, 2015). Of course, such a simple comparison in the amount of data between Baidu and National Library may not be appropriate, because the National Library has a greater advantage in the quality and specification of data, and now the National Library also collects plenty of digital resources, image video materials and information from the Internet. The comparison in the amount of data here is to attract the attention of librarians, and remind the traditional library industry of the situation.

Above all, due to the rapid construction of academic, educational, and cultural resources by the network resource providers, they have surpassed traditional digital libraries from either the scale or the types of resources. Resource development is further deepened and services are diversified by providers. Traditional digital libraries will face even greater challenge in their future development. How to survive and develop instead of being replaced is a rising issue which digital libraries must pay attention to.

The challenge, of course, can also become an opportunity to the library. Using the opportunity introduced by the big data era, we can refresh our conventional understanding regarding to resources, resource organization, technologies, services and functions, re-design the architecture of a digital library, and convert the challenge into the opportunity of another boom. This is the objective of this paper.

1 Related research and enlightenment

In a big data era, people's mindset has undergone a fundamental change. So the construction of a digital library shall also adopt the mindset of big data. In order to get the enlightenment from related studies, the author searched the domestic full-text database CNKI and oversea full-text database EBSCO, and retrieved over 40 and 20 papers relevant to big data and digital libraries respectively. Among those papers, the number of papers closely associated with big data and digital libraries was slightly more than 10, of which only several from overseas. However, these papers had given us certain insight in the discussion of the future of digital libraries.

1.1 Related domestic and oversea statement

In the era of big data, people persistently explore the fusion point of big data and digital libraries. Foreign scholars did a lot of research from theory, technology and application aspects. For instance, Huwe (2014) from the library of the University of California, Berkeley, pointed out in his paper "Building digital libraries: big data and the library" that, big data and libraries were a union made by heaven; the user-oriented research projects of librarians were especially adaptable to big data, so the information acquisition of digital libraries on user behavior should be strengthened. Renaud from the University of California, Irvine, Britton and others from the Massachusetts Institute of Technology (Renaud, Britton, D. Wang, & Ogihara, 2015) used big data technology to deeply explore the behavior of university digital library users, and help the university in its correlation analysis of students' reading behavior and related information. In terms of technology, Borgman, Wallis, Mayernik, and Pepe (2007) from the University of California, Los Angeles adopted embedded technology, embedded sensors in the digital library system, collected relevant data, so provided data for researchers to carry out research, and added new function to the digital

library. There are many other scholars who have begun to focus on the gathering, processing and associating functions of digital libraries for the academic information in big data (Williams, Wu, Choudhury, Khabisa, & Giles, 2014), so digital libraries can make better use of big data and incorporate to the Internet.

At the same time, plenty of relevant achievements and ideas also have been published by domestic researchers. For example, Zeng (2004) pointed out in the preface of album "Big data and digital libraries" of "Digital Library Forum" that, big data was bound to promote the in-depth revolution of a digital library in data management, data analysis, data use and data services, in the meantime put forward higher requirements to the responsibility and consciousness of librarians. C. F. Chen, Qian, and Dai (2014) from the Wuhan University analyzed the problems of digital libraries currently facing in this big data environment, and proposed relevant suggestions and countermeasures from aspects like transformation of mindset, development of knowledge service, enhancement of financial input mechanism, and improvement of librarians' quality, etc. Liu, Xia, and C. J. Zhang (2013) from the Shanghai Library emphasized the importance of digital libraries focusing on big data and associated data in the era of big data, and outlooked the application prospect of two different correlation data, i.e. big correlation data and correlated big data in digital libraries. C. Chen (2015b) from the Lanzhou University of Finance and Economics explored how to establish an effective digital library search engine, which can meet the personalized demand of library users from a technical perspective. There were also a lot of research works done in other aspects of the application of big data technology in digital libraries. M. Chen, Zhou, & Lü (2014) investigated the mobile data service technology of digital libraries in a big data era. C. Chen (2015a), Li and X. Y. Zhang (2013) discussed the big data storage issue in digital libraries. Guo (2015) dabbled the unstructured data fusion problem in a big data environment. Y. G. Wang, Xing, and H. Zhang (2014) explored the architecture problem of the application of big data technology in digital libraries.

The researches above revealed that the challenges and opportunities introduced by big data to digital libraries had attracted the attention of academic researchers and library staffs. Researches and practices of digital libraries incorporating big data are on-going. To achieve a better development of university libraries and public libraries in the big data era, and for them to play a more important role in people's cultural life and scientific research, we must think deeper, change mindset, and promote competitiveness.

1.2 Enlightenment and reflection

Academic resource construction business rapidly progresses in the big data era. It is not just limited to Internet resources and journals, but includes all types of literature resources. The resource network is not just a simple literature network either, but is established as a network between

literatures (referenced, co-referenced, reference coupled, etc.), between authors and literatures, and between the use of literatures and scholars. These are not yet achieved by traditional digital libraries. With the enrichment of academic resources, these resource constructors are likely to outperform the traditional digital libraries, even replace the digital libraries founded in university libraries and public libraries.

Therefore, digital libraries should pay attention to this trend, and consider the challenge from resource construction business as an opportunity to another boom. They can learn from the experience of resource constructors and start from resource acquisition, diversifying the categories of digital library resources, strengthening the integration of various resources, exploring the correlation between these resources, and organizing them properly. They can also discover the value of the resources and make full use of data through in-depth mining on the acquired data and its potential rules, and in-depth analysis of relevant data for its intrinsic value. Besides, digital libraries must also learn from resource constructors in their experience in services, provide a variety of services, and change the traditional passive (i.e. providing what users ask for) and waiting (for users to raise the requirement) service mode.

In the big data era, we must have it in mind that everything of traditional digital libraries needs a change to become more adaptable to big data, make full use of big data, get involved in big data, and promote the influence of digital libraries in people's study, life, work, and research.

2 Thinking by numbers of digital libraries

"Thinking by numbers" requires digital libraries to consider all kinds of problems from the angle of big data, completely get involved in big data, increase the quantity of digital products, upgrade service levels, solve problems in aid of big data technology, and become an essential part of "Internet +".

2.1 Digital library resource construction

In the big data era, digital libraries should adopt a different thinking in their resource constructions. They should expand the resource scope, combine the resources with Internet resources, emphasize complex trouble-shooting oriented resource integration and resource processing, and establish a brand new view for resource construction.

(1) Expand the resource scope of digital libraries

The service quality and service level of digital libraries rely on digital resources. In fact, digital libraries have focused on resource constructions, but only limited to literature resources, such as books, journals, newspapers, dissertations, conference papers, patents, standards, technology reports, etc. In the big data era, in addition to the digitalization of above literatures and increment

of database resources, digital libraries should also include government information, society-concerned information, Internet hot topics, as well as user behaviors like use of digital libraries and network search, as part of their data collections. Moreover, digital libraries should also increase the production, collection and storage of renewable resources, including the various types of integrated data after correlation, mining and analysis, and finally diversify their data resource categories.

(2) Spread the resource integration of digital libraries

The unique feature of big data is the complexity and diversity of data. Pure literature information could not meet the needs of digital library users, which inevitably leads to the conversion of resource integration from pure literature service to comprehensive information service. In order to meet various needs of users, we need to integrate literature information, government information, social information, network information, and user information. In other words, we need to associate digital library resources with social resources, especially the social resources of public concern.

In addition, we also need to strengthen the resource integration oriented to complex problem solving. In a big data environment, users expect digital libraries to help or guide them solving practical and complex problems instead of simply meeting their demands related to literatures. Therefore, the traditional resource integration based on simple accumulation and classification is confronting great challenge. To meet the actual needs of users, we must carry out the resource integration oriented to complex problem solving.

(3) Deepen the resource organization and processing of digital libraries

Resource organization and processing arrange the sequence of resources, coming up with a presentation of resources in the form of knowledge. In digital libraries, structured information (e.g. bibliographic information) itself has certain forms of knowledge presentation, which is basically restricted within the repository. In a big data environment, we must widen the views, establish a semantic link between internal and external resources of digital libraries, and construct a complete social resource oriented digital library resource organization architecture.

In addition, for the purpose of further deepening the processing of library resources, we must upgrade from deconstructive processing of information to constructive processing of information. For example, we can break down the literature into knowledge units (knowledge deconstruction), establish semantic association among these knowledge units or between these units and the literature (knowledge construction), and then produce new knowledge. In the deconstruction and construction process of knowledge, we should make use of data mining technology and analysis software, and improve the capability to apply and share the produced subject headings and classification charts.

In the resource organization and processing of digital libraries, another non-literature resource should draw our attention, which is the user behavior information. User behavior information is a precious resource in the knowledge service and knowledge recommendation of digital libraries and requires deep exploration and proper organization. If the user behavior data is closely associated

with other resources like literature resources and target resources, it will become a highly efficient resource of knowledge service.

2.2 *Application of digital library technology*

In the big data era, digital library technology has migrated from local data processing to data processing of a wider field. From the perspective of the technology system of digital libraries, it includes data acquisition, data processing, architecture construction, knowledge mining, analysis, prediction, result presentation, service technology, etc. How to apply and incorporate big data related technology into digital library field, is now a problem faced by the digital library field.

(1) Semantic technology

The big data environment needs semantic technology to help connect the large quantity of complicated data. Digital libraries should think about how to automatically fuse the semantics defined in dictionaries (subject headings, classification charts, etc.) into the related information of digital literatures. Of course it is not practical to label manually the semantic relations of such a large amount of data. With the aid of dictionaries, we must adopt artificial intelligence technology, ontology, semantic analysis technology, automatically label the semantic relations of data and make the data meaningful so as to promote the knowledge expansion and knowledge exploration of the collected resources.

The application of semantic technology in the field of book intelligence is not uncommon. Tools like book classification and Chinese Thesauri were created based on semantic relations. But these tools only help us define the semantic relations between literatures rather than the semantic relations among the knowledge points inside the literature or information which is required in a big data environment. The establishment of the semantic relations among knowledge points can facilitate users' access to knowledge, and open a channel for them to obtain the useful knowledge through keywords and semantic relations.

(2) Data clustering technology

Clustering is a process which puts similar and related information or data together. It is one of the effective means of efficient utilization of multifarious and a huge amount of data. In digital libraries, clustered information resources can play a more significant role in information service, information analysis and information utilization. Clustering technology can not only gather literature information resources according to certain attributes or characteristics, but also be applied to user requirements, user search behavior processing and analysis.

In a big data environment, only a small portion of data is utilized. Clustering technology provides a good way of full usage of this small portion of data. For instance, the clustering of data resources can separate them into small data sets of close relations and similar themes, and these small data sets are perfect for problem oriented demand, as well as users' retrieval, selection and

analysis of information, The clustering of user needs can help us compare and analyze similar demands, help users optimize their demands, and promote the expression of demands. The clustering of user behaviors can find the law of user behaviors of resource usage, and provide data support for user personalized recommendation service.

(3) Information analysis techniques

Digital libraries of the big data era should make full use of information analysis techniques, incorporate big data analysis technology into digital libraries, regard data analysis as a development work of digital libraries, and take the analysis results as the high-end products provided to users. Among these analysis techniques, literature information compiling technology can provide support for tracking of cutting-edge research; On-line Analytical Processing (OLAP) can online analyze users' behaviors of digital library usage, and provide data support for the management and operation of digital libraries; other quantitative and qualitative analysis tools and techniques, such as Hadoop, SPSS, CiteSpace, etc. should also be fully utilized by digital libraries.

(4) Retrieval technology

The retrieval technology deployed by next generation digital libraries should not be constrained to index to a single digital library, but realize seamless cross-platform and cross-resource retrieval using network retrieval technology. This requires a retrieval network between the digital libraries. Each digital library can achieve internal and external resource retrieval and provide network resources. In the meantime, academic search should become a product offered by digital libraries in universities and research institutes, in order to promote the academic research of their staffs. Due to the self-service pattern of the usage and retrieval of digital libraries, the retrieval interface should be made user-friendly with more powerful functions, such as semantic retrieval, conversational language retrieval and cross-language retrieval which can automatically understand or translate multiple languages.

2.3 Product and service mode of digital libraries

Literature information cannot completely meet the demands of users in the big data era. Users now need more diversified information. In addition to officially published literature information, they also need videos, images, unofficially published information and network information, even regenerated information.

(1) Digital library service products

Academic resource constructors are providing more types of products, which almost include all of the digital library resources and are constantly expanding, making a bigger impact on digital libraries. Therefore, next generation digital libraries must offer more diversified products to be more competitive. Besides literature and network information services, digital libraries should be able to provide renewable information services, such as knowledge base, method library, inference