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Next-Generation Library System Platforms: Practices and Reflections (Postprint)

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Abstract

[Purpose/Significance] Big data and artificial intelligence technologies present both opportunities and challenges for smart library services, making the construction of new library system platforms imperative. This study aims to explore the current development status and countermeasures of next-generation library system platforms, providing practical cases and reference frameworks for building first-class university smart libraries. [Method/Process] By reviewing the development trajectory of library system platforms and taking stock of existing research and practices on next-generation library system platforms both domestically and internationally, this paper explores the construction scheme for new library system platforms using Nanjing University as a case study. [Results/Conclusion] Smart libraries will enhance resource management control and knowledge service levels, and build an open and shared smart library service system through the construction of an integrated electronic resource management platform and the development of NLSP.

Full Text

Practice and Reflection on Next-Generation Library System Platforms

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Abstract: [Purpose/significance] Big data, artificial intelligence, and other technologies bring both opportunities and challenges to smart library services, making the construction of new library system platforms imperative. This paper aims to explore the development status and strategies for next-generation

library system platforms, providing practical cases and reference foundations for building first-class university smart libraries. [Method/process] By reviewing the evolution of library system platforms and surveying existing research and practice on next-generation library system platforms both domestically and internationally, this paper uses Nanjing University as a case study to explore construction schemes for new library system platforms. [Result/conclusion] Smart libraries will enhance resource management control and knowledge service levels by building integrated electronic resource management platforms and developing NLSP, constructing an open and shared smart library service system.

Keywords: library system platform; smart library; smart service; electronic resource management; NLSP

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In 2017, the NMC Horizon Report: Library Edition [1] identified key technology trends that would impact academic research libraries within five years, including big data technology, library service platforms, and artificial intelligence, which would significantly promote transformation in academic libraries. As early as 2013, the IFLA Big Data Trend Report [2] predicted that big data analytics would greatly influence future public service sectors and become one of the important technologies. As big data technology matured, libraries increasingly valued data resources and data technology, gradually applying them to resource construction, library management, and services. In 2016, Civic Technologies conducted a big data user project study across ten libraries in the United States, producing the first big data user report in the library field by integrating data resources and technology to fully mine user data value [3]. Big data technology is profoundly affecting library operations and services.

The big data wave continues to rise while the era of artificial intelligence has quietly arrived. In 2018, China's government work report identified "implementing big data development initiatives and strengthening new-generation artificial intelligence research and application" [4] as important government objectives. Today, artificial intelligence has demonstrated outstanding performance in urban construction, smart homes, education, and other sectors. Many university libraries are keeping pace with the times, fully utilizing artificial intelligence technology to continuously transform toward smart libraries. Nanjing University's smart library research and development products—the consulting service robot "Tubao" and the book inventory robot "Tuke"—represent major innovative breakthroughs in the application of artificial intelligence robot technology in domestic libraries [5]. Tsinghua University has effectively combined intelligent vehicle autonomous driving technology with daily library operations based on artificial intelligence algorithms, enhancing the intelligence level of library services [6]. Additionally, domestic internet companies such as Baidu Education are entering the promising smart library market, using artificial intelligence, big data, and cloud computing to comprehensively build smart libraries. Artificial intelligence technology will lead libraries from the resource provision era to the

knowledge service era, and smart libraries centered on AI and targeting user core demands in different scenarios represent an irreversible development trend.

Big data, artificial intelligence, and other technologies have enabled libraries to break free from their current situation of low service efficiency, providing technical and equipment support for collecting massive and complex data, and bringing opportunities for smart library services—along with challenges. To adapt to development, libraries continuously expand hardware scale and update information management systems and purchase electronic resources. Although overall capacity continues to expand and upgrade, service capabilities have not improved proportionally. Existing library system platform construction cannot keep pace with the growth rate of resources and service demands. Redundant and blind construction has made library information systems increasingly complex, with low usage rates, seriously constraining the development and progress of library knowledge services and resource management. Today, new technologies and platforms can effectively and orderly solve the difficulties faced by library information construction, and new library systems are emerging. However, what is the specific positioning of next-generation library system platforms? How can they be integrated and upgraded to better serve library work? What are the difficulties and solutions in the promotion process, and what are the future prospects? These questions surrounding next-generation library system platforms have become focal points of discussion in the library community. This paper reviews the evolution of library system platforms, surveys existing domestic and international practice and research on next-generation library system platforms, discusses difficulties and countermeasures in their development, and uses Nanjing University's attempts and practices as examples to provide practical cases and references for building new system platforms for first-class university smart libraries.

1. Current Development Status of Library System Platforms at Home and Abroad

1.1 Evolution of Library System Platforms

Library system platforms originated from library automation management systems. In the 1970s, OCLC and BALLOTS, prototypes of library automation management systems based on online cataloging, took shape successively. As computer and network technologies matured, Northwestern University's NOTIS library automation system was successfully developed in the 1980s in the United States, and specialized library automation system providers emerged, gradually transforming library automation systems from independent school developments into commercial products. Well-known commercial library automation systems include Horizon, Unicorn, Millennium, and Aleph500, alongside open-source automation systems such as Koha, Evergreen, and OPALS [7]. Many Chinese libraries have introduced high-level automation management systems to improve management capabilities and service levels, with university libraries such as

Peking University, Tsinghua University, Shanghai Jiao Tong University, and Tianjin University introducing foreign library automation management systems like INNOPAC and SARIS [8]. Although China's independent development of automation management systems started late, more than a dozen systems have been launched and put into use through continuous effort, with mainstream domestic products including the Huiwen Library Information Service System (Libsys2000) [9]. Despite being unable to compete with foreign professional companies in terms of technology and market scale, most domestic systems have basically met the functional requirements of Chinese libraries in terms [10] of automated acquisition management, computer cataloging replacing manual cataloging, automated circulation, public catalog retrieval, and periodical management. However, such traditional library system platforms were born in the era of print-resource dominance. As electronic resources began to occupy an increasingly large share of collections, existing library automation systems exposed their inability to manage electronic resources, while the shift from print to electronic collections impacted the work of acquisition and cataloging librarians, and library automation systems faced increasing questions and challenges [11].

To address these issues, Electronic Resource Management Systems (ERMS) emerged, primarily used to manage various data and metadata related to library electronic resources. Their appearance solved the problem that traditional library automation management systems could not manage electronic resources such as e-journals, e-books, bibliographic databases, and full-text databases. ERMS were initially independently developed by foreign university libraries according to their own needs, with well-known examples including VERA (Virtual Electronic Resource Access) developed by MIT, ERLIC (Electronic Resource Licensing and Information Center) developed by Pennsylvania State University, and HERMES (Hopkins Electronic Resource Management System) developed by Johns Hopkins University [12]. With the formation of the Electronic Resources Management Initiative (ERMI) [13] by the Digital Library Federation and the National Information Standards Organization's joint working group, the development of electronic resource management systems began. Subsequently, library software developers joined ERMS development, and commercial ERMS products continuously emerged, with major representatives including ERM (Innovative Interfaces), Verde (Ex Libris), and 360 Resource Manager (Serials Solutions) [14]. Domestic practice in electronic resource management systems began with attempts by university libraries. Tsinghua University Library, the National Library, and Wuhan University Library introduced Ex Libris' electronic resource management system Verde, but because foreign ERMS could not fully meet the actual needs of domestic libraries—for example, lacking Chinese knowledge bases and being difficult to match with domestic procurement processes—they were not fully implemented [15]. In 2011, based on extensive research of domestic and foreign products, Shenzhen University Library independently developed the first open-source electronic resource management system (Open_{ERM}) suitable for China's actual conditions and capable of meeting

regional cooperation needs [16].

The implementation and application of ERMS improved work efficiency, but foreign ERMS construction also continuously reflected on thorny issues such as data standards, workflow management, interoperability [17], and license information processing [18]. These deficiencies also promoted system improvements. In recent years, as library services and business scopes continue to expand, library system platforms have also continuously developed, with electronic resource management systems and integrated automation system functions gradually merging. Some ERMS have emerged as built-in systems within integrated management systems [19], and a new type of integrated management and service system, electronic resource management, and knowledge base products have gradually gained favor among many libraries, which the industry calls “next-generation library system platforms” or “next-generation library service platforms.”

1.2 The Rise of Next-Generation Library Systems

With changing resource environments and increasing reader demands, a new generation of library systems integrating seamless management of print and electronic resources and merging integrated management systems with electronic resource management functions has become necessary for the times. Compared with traditional systems, next-generation systems focus on functions (see Figure 1 [Figure 1: see original paper]) and features including:

- (1) High openness and integrability. Libraries are distribution centers for various types of resources and knowledge information, as well as centers for public cultural services and information services. Next-generation library systems fully integrate services and resources, not only managing collection resources but also optimizing workflows and facilitating interaction with readers through the system, promoting library resource construction.
- (2) Extensive application of new technologies. Technology development often drives library progress. The emergence and development of the Internet have pushed library system construction to focus more on being user-centered. Big data and artificial intelligence technologies enable libraries to provide more precise services, creating greater harmony between users and the library. Next-generation library systems adopt SOA, SaaS, and cloud computing technologies [20], big data, and artificial intelligence, using these modern technologies to provide readers with more comprehensive and powerful knowledge services.

Currently, well-known related system products in the foreign market include Alma (Ex Libris), WMS (OCLC), Sierra (Innovative Interfaces), Intota (Serials Solutions), Open Library Environment (Kuali), Open Skies (VTLS), and BLUEcloud Suite (SirsiDynix) [21]. Additionally, there is an open-source library service platform—FOLIO (the future of libraries is open)—that uses machine learning and other new technologies to improve interoperability and user

services, continuously attempting to redefine library service platforms [22].

Although such products have been launched and used in the market for more than six years, next-generation library system platforms like Alma, which can provide unified solutions integrating print resources, electronic resources, digital asset management, metadata management, and resource discovery in one system, optimize workflows and collections, support multiple standards, drive user participation in resource construction, and provide remote services based on the cloud [23], are becoming new choices for libraries. Today, foreign systems widely used in the Chinese market include Intota and Alma, with many domestic university libraries such as Tsinghua University, Chinese University of Hong Kong (Shenzhen), and Beijing Normal University having launched next-generation library systems. In 2017, Beijing Normal University Library introduced the next-generation library system Alma, attempting to reorganize business, improve processes, enhance efficiency, and develop new services through system implementation [24].

Meanwhile, as smart library concepts and practices continue to mature, many university libraries, related organizations, and data providers are attempting to independently develop next-generation smart library systems, using big data analytics and other technologies to explore smart library portals that highly integrate resources, readers, and services [25]. Chongqing University has adopted a “platform-based” construction as its core, using integrated literature search as the foundation, and implemented comprehensive informationization of management and services through an architecture comprising user layer, service and management layer, resource layer, and evaluation and analysis layer (data service layer) [26]. Chongqing VIP Information Company has also partnered with Chongqing University to build a digital campus teaching and research application library service portal and will collaborate with other domestic universities to construct next-generation library systems [27]. Shenzhen University Library is exploring and developing a new OLE system based on Quali’s RICE framework [28]. Other next-generation system platforms such as Jiangsu Tustar’s Libstar library system platform, Wuhan Sanxin Cloud Platform, and Jiangsu Yangge ERM platform have fully integrated big data technology and artificial intelligence to independently develop next-generation smart library system platforms with more complete architectures and more powerful functions.

Although current domestic research on next-generation library systems mostly focuses on theoretical aspects such as introducing foreign product functions and practical experience, theoretical principle design, and development [29], with fewer practical experience studies, various developers led by university libraries are actively participating in the research and construction of next-generation smart library system platforms, meeting user needs in the current new technology environment where big data and artificial intelligence are rising, and continuously improving the core service capabilities of libraries.

2. Difficulties and Countermeasures in Next-Generation Library System Platforms

Based on research and practical experience related to next-generation library systems, many difficulties remain in the process of building new platforms, mainly including:

2.1 Standardization Systems Need Improvement

Liu Wei [30] once mentioned that “the root cause of today’s library systems being difficult to shape lies in the lack of uniformly standardized data formats and universally standardized business processes.” In the information construction of next-generation library systems, there are large amounts of interactive operations and data exchanges, as well as metadata for library information carriers. Without relevant scientific standards to regulate statistical methods, integration standards, management, and cleaning, each system becomes its own island, hindering the sustainable development of next-generation library systems.

2.2 Users Lack Autonomous Choice

Due to the limited number of developers for next-generation library system platforms, barriers exist between various system vendors, each being independent and non-universal product lines. Therefore, vendors adopt an all-in-one product design model for next-generation systems, causing users to lose autonomous choice for segmented products. Additionally, for domestic library users, appropriate product pricing is also an important reference factor, but some product prices are divorced from the domestic market, hindering the promotion and application of next-generation library systems.

2.3 Difficult Migration and Deployment

The construction of new system platforms means the updating and iteration of old systems. After system replacement, subsequent management and deployment present significant difficulties. First, although complete new systems have not yet been fully promoted domestically, some modules such as ProQuest’s Summon discovery service and Primo resource discovery and delivery are already in use [31]. Replacing and integrating these diverse systems cannot be accomplished in one step, and the entire implementation process has a long cycle. Second, using new systems requires large-scale data migration, during which data loss may occur. Additionally, in the implementation and deployment of new systems, numerous third-party data interfaces surrounding library systems require secondary development or procurement, such as interfaces for campus cards, digital campuses, and self-service borrowing devices.

2.4 Incompatible Business Processes

The development process of existing foreign system products is oriented toward commercial interests without investigating the local library environment, and manufacturers lack local support. Therefore, many processes in the introduced new system platforms are not adapted to actual domestic market needs and require secondary patch development by local vendors. Additionally, for users, next-generation system products have significant differences in both technical architecture and product functions, requiring readaptation to new system interfaces and business processes. Some systems apply microservice concepts and adopt real-time online operation models, which place higher demands on after-sales support personnel.

2.5 Information Security Risks from Cloud Deployment

Cloud services are the primary resource and service presentation form for next-generation library system platforms. How to securely deploy digital resources and digital assets in cloud environments is an issue that every library should 重视. Information security risks come from two aspects: first, the integrity and security of data assets during network transmission, and the management and protection of digital resource intellectual property rights, such as data loss or leakage, and copyright conflicts arising from cloud service providers using migrated collection data to develop new products; second, the issue of libraries as service subjects having control over data. Libraries should have absolute guardianship and control rights over collection data and user data, but in reality, this data is controlled by cloud service providers, creating risks of being used or illegally leaked to third parties [32].

Although there are many difficulties in building next-generation library system platforms, open library platforms represent the general trend. Actively seeking countermeasures better demonstrates libraries' service capabilities and core values. First, building standardized metadata structure storage specifications and standardized data exchange interface specifications is fundamental. Second, promoting the localization of library system construction—CALIS (China Academic Library & Information System) and JALIS (Jiangsu Academic Library & Information System) can actively strive for dominance in development and market operations. Meanwhile, domestic library system developers should strengthen independent innovation and even form strong alliances to accelerate the research and development process of next-generation systems, making products more suited to domestic market needs and no longer subject to foreign vendors. Finally, for libraries themselves, externally they should master data autonomy through contract agreements and encrypted collection data so that data is not controlled by vendors; internally they should optimize migration and deployment processes, use new technologies to ensure data information security, focus on cultivating senior operators for new system platforms, and build smart library service systems with open sharing and good interaction among multiple vendors and institutions.

3. Development and Practice of Smart Library System Platforms

Nanjing University has continuously explored and innovated smart library practices. While persistently developing library robots such as the UHF RFID intelligent book inventory robot “Tuke” [33] and the consulting service robot “Tubao,” the library has never stopped attempting to build next-generation smart library system platforms. Nanjing University Library plans to attempt building a smart library new platform through two schemes.

3.1 Building an Integrated Electronic Resource Service System

Resource construction is the foundation of library development. Traditional print resources occupy large amounts of library physical storage space, with increasing funding and space pressures. Meanwhile, the growing volume of electronic resources has made managing multiple resource types a challenge, and libraries urgently need to achieve transformation in information resource integration. Currently, achieving print-electronic integration and building an integrated electronic resource service system represents the major trend in library resource construction. The essence of print-electronic integration is the merging of print resource metadata repositories and electronic resource metadata repositories. After merging, it can achieve duplicate checking in both print and electronic systems during procurement, merge displays of print and electronic versions of the same publication, unify retrieval and mixed result ranking of print-electronic publications at the publication level, and support cataloging and display of multiple metadata formats such as MARC, DC, and RDA.

Nanjing University Library builds an integrated electronic resource service system using a multi-system combination and customized model of “print resource management system + electronic resource management system + resource discovery service” to meet most functional requirements of next-generation library systems. This unified management system with multi-level services and inter-related data breaks the previous pattern of isolated system operation. Relying on the integrated electronic resource service system, users can find required databases and publications through resource navigation, access subject homepages, and obtain full text through diversified methods such as Discover discovery service. Libraries can use the electronic resource management system to manage metadata at three levels: databases, subscription units, and publications; manage library-held databases, data packages, and publication database comparative analysis; and comprehensively manage complete processes including resource trials, evaluation, ordering, activation, contract management, and renewals. By customizing subject homepages for departments and deeply integrating with discovery services, libraries can improve subject resource guarantee rates for core electronic resources and conduct subject resource construction. The system automatically harvests vendor Counter usage statistics, collects usage statistics from resource navigation and remote access systems, and automatically analyzes database sub-publication literature cited in the university’s

published research. Using the print resource management system + electronic resource management system + discovery service model currently achieves most main functions of next-generation library systems. Compared with existing foreign next-generation systems, it is more integrated, flexible, and localized (see Table 1), laying a solid foundation for advancing future smart library system construction that is shared, open, and collaboratively built.

3.2 Building a Next-Generation Library Service Platform (NLSP)

Integrating resources and services is the goal and task of next-generation smart library system platforms, and smart services require advanced technology and complete platform support. Nanjing University Library has innovatively cooperated with Jiangsu Tustar Software Technology Co., Ltd. to build a new-generation smart library service system platform (NLSP), which has achieved phased practical results. NLSP mainly integrates four modules: central knowledge base, acquisition platform, librarian smart service platform, and reader application service platform.

3.2.1 Central Knowledge Base. Knowledge base construction and maintenance are important factors affecting successful system platform implementation and application. Currently, multiple alliances, organizations, or data providers have cooperatively built open knowledge bases, such as the “Global Open Knowledge Base” jointly developed by Kuali OLE and the UK’s Joint Information Systems Committee (JISC) [34]. Nanjing University Library envisions building a central knowledge base for electronic resources encyclopedia to achieve collaborative knowledge base construction and sharing. This central knowledge base includes various resources such as books, journals, papers, and patents, as well as resource packages, supplier management, license agreements, and link resolver functions, with regular data updates. The platform interface is open, supporting KBART2 and OAI standard metadata exchange, and supporting indexing by SCI, SSCI, EI, ISTP, Scopus, Pubmed, etc.

3.2.2 Acquisition Platform. Libraries purchasing print or electronic resources often use book catalog information sharing platforms connecting library vendors upstream and downstream. Well-known market products include “Changxiang Zhixing” from People’s Century Books [35], “Yuntian Zhihui” from Wuhan Sanxin [36], and “Yuntai Gou” from Zhejiang Xinhua Bookstore [37]. However, current similar products have uneven functions—some platforms only purchase e-books, some only handle print books, and some focus on print with attempted print-electronic synchronization. Meanwhile, most platforms do not involve management of electronic resources like databases. This dispersed purchasing and management results in complex acquisition processes, low efficiency, and even acquisition omissions or duplication. To address these issues, Nanjing University Library plans to use cloud computing and big data analysis platforms to achieve integrated intelligent procurement management of print resources, electronic resources, and digital resources. During the entire acquisition process, multiple libraries collaborate in procurement, with the main library issuing

purchase orders and member libraries selecting directly. The platform supports intelligent book selection functions for multiple procurement strategies (subject, classification, etc.), multiple screening conditions, and can compare purchase lists based on librarian scoring clouds. During catalog browsing, relying on central knowledge base data support, it automatically obtains metadata, cover images, electronic full text, tables of contents, and abstracts. The platform also supports one-time and continuous receipt of physical resources, as well as package activation of e-books, e-journals, and electronic resources with automatic release, making the procurement process more integrated and smooth.

3.2.3 Librarian Smart Service Platform. Smart services are reader-demand-driven and demonstrate intelligence in all aspects from management to librarians. Librarians' information services and management involve resource acquisition, resource management, system monitoring, resource archiving, reader services, and analysis decision-making, all integrated into the new system platform for unified operation. For example, in the integrated resource management process, the platform establishes standards and process systems for harvesting, integrating, cleaning, and storing multiple metadata formats including CNMARC, USMARC, RDA, DC, and RDF, integrating electronic resource management (ERMI), link resolver management, cloud and local storage digital asset management, and print resource management (ILS), making librarian operations more convenient and efficient.

3.2.4 Reader Application Service Platform. Building library intelligence services driven by reader needs is the library's purpose. The new library system platform provides not only basic services such as resource discovery and full-text reading but also meets readers' personalized needs through patron-driven acquisition (PDA) services to achieve precise services. Additionally, big data processing technology and machine learning and other artificial intelligence technologies are gradually applied to smart library services, providing readers with smarter service forms. For example, using big data processing technology to collect data sources from databases and logs, import and clean them, use distributed databases or computing clusters to analyze and summarize data, and apply various algorithms including K-Means for clustering, SVM for statistical learning, and Naive Bayes for classification for mining, deeply studying user behavior to provide customized services for readers.

The two schemes have been under development for more than a year, both using social cooperation methods. The main functions of the new platform have been completed, along with data analysis of the original system platform, bibliographic data organization, and data migration to the new system, achieving expected goals and entering the system evaluation and librarian training stage.

After decades of development, library systems have continuously improved their functions under the promotion of new technologies and market testing. Particularly in the current new technology environment where big data and artificial intelligence are rising, next-generation library system platforms have enormous development potential and will push library systems to a new stage. Currently,

smart library system platforms are in the initial application stage, and Nanjing University's research and construction of smart library new system platforms have begun to take shape, making the future of next-generation library system platforms promising. It is hoped that more libraries will adhere to people-oriented concepts, aggregate user needs, collaborate with multiple vendors and institutions, build standard-specified, open, and shared smart library service systems, continuously improve core service capabilities, and contribute to building first-class library new system platforms and first-class university smart libraries.

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