Research on the Path of Precision Information Services in University Libraries under Blockchain Technology (Postprint)

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Abstract

[Purpose/Significance] This study explores the application value of blockchain technology in precision information services within university libraries, aiming to fully leverage this technology to enhance service effectiveness and expand service domains. [Method/Process] It analyzes the existing challenges in the precision information service processes of university libraries, as well as the necessity and feasibility of introducing blockchain technology, thereby proposing pathways for precision information services. [Results/Conclusion] This study integrates blockchain with precision information services in university libraries: utilizing the decentralized nature of blockchain to construct a blockchain consortium system for library precision services; capitalizing on the information symmetry characteristic of blockchain and integrating xAPI technical specifications to establish a blockchain-based storage platform for library information services; exploiting the traceability feature of blockchain to build a traceability system for library precision information services; and harnessing the advantages of blockchain' s cryptographic algorithms for data storage to establish institutional repository data sharing services.

Full Text

Research on the Path of Precision Information Services in University Libraries Under Blockchain Technology

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Abstract:
[Purpose/Significance] This study explores the application value of blockchain technology in precision information services within university libraries, aiming to leverage this technology to enhance service efficiency and expand service

domains. [Method/Process] We analyze the problems existing in current university library precision information service processes and examine the necessity and feasibility of introducing blockchain technology to derive an effective service path. [Result/Conclusion] This research integrates blockchain with university library precision information services by: (1) utilizing blockchain' s decentralized characteristics to construct a blockchain alliance system for library precision services; (2) leveraging blockchain' s information symmetry features, combined with xAPI technical specifications, to establish a blockchain-based library information service storage platform; (3) employing blockchain's traceability features to create a library precision information service traceability system; and (4) harnessing the data storage advantages of blockchain' s cryptographic algorithms to establish institutional repository data sharing services.

Keywords: blockchain; university libraries; precision information service
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Blockchain technology, originally proposed as the underlying infrastructure for Bitcoin in 2008 by Satoshi Nakamoto in the paper "Bitcoin: A Peer-to-Peer Electronic Cash System" [1], remained largely unnoticed until 2016 when it gained global attention due to its technological advantages. In October 2016, the China Blockchain Technology and Industry Development Forum, under the guidance of the Information Technology and Software Services Department of China' s Ministry of Industry and Information Technology, published the "White Paper on Blockchain Technology and Application Development in China (2016)" [2], which served as an official guiding document that accelerated the development of blockchain technology and related industries in China. In October 2019, President Xi Jinping emphasized during the 18th collective study session of the Political Bureau of the CPC Central Committee that blockchain should be treated as a core technology for independent innovation, urging accelerated development of blockchain technology and industrial innovation, and promoting its integration with economic and social development. He specifically called for exploring blockchain applications in livelihood areas such as education, employment, healthcare, and social assistance to provide smarter, more convenient, and higher-quality public services [3]. This marked blockchain' s elevation to a national development strategy, receiving support from relevant policies.

2. Related Research

2.1 Research on Library Precision Services

Scholars have examined library precision services from various perspectives. Cao Shujin, Liu Huiyun, and Wang Lianxi argue that library precision services are user-demand-oriented, maximizing the use of advanced technologies and methods such as big data and artificial intelligence to collect, process, and analyze library big data, thereby uncovering users' actual or potential needs and providing customized, differentiated, and personalized services [4]. Chu Jiewang and

Wang Min emphasize that precision services focus on service accuracy and user experience, establishing a new service concept centered on users, supported by technology, and dominated by personalized customization [5]. Wu Jianzhong [6] views precision services as both a product of the big data era and closely related to high-quality development. In essence, library precision services represent an "upgraded version" of personalized services rather than an entirely new model.

Research in this area differs between domestic and international contexts. International studies primarily focus on the technical aspects, examining library precision services from user identification to service function optimization and innovative service models throughout the entire process. C. Porcel and E. V. Herrera [7] proposed a fuzzy language recommendation system to describe and capture user preference features, enabling cluster analysis for precise user identification. S. C. Kao and C. Wu [8] developed a personalized knowledge integration platform offering personalized knowledge integration and thematic services, allowing users to share knowledge online according to thematic categories. S. Brown et al. [9] studied research data from the University of Queensland' s institutional repository, establishing a service model where subject librarians deeply engage with researchers to provide research data management services, thereby driving the development of research support services at the university library.

Domestic research, based on published literature, concentrates on big data, small data, user profiling, and scenarios. Niu Yong [10] proposes that the key to constructing library precision services lies in two aspects: resource allocation based on big data and service provision based on small data. Kang Cunhui and Cao Juhua [11] suggest promoting library precision services through constructing big data resource communities, improving big data analysis and prediction mechanisms, introducing differentiated theories, and advancing user profiling. Wang Dongliang et al. [12] identify four main areas of user profiling research: construction processes, precision services, precision recommendations, and practical applications. Ge Yanjun [13] constructs a scenario-based library precision service support framework from a practical perspective.

2.2 Blockchain Technology in Library Information Services

Blockchain technology is a new decentralized infrastructure and distributed computing paradigm that uses encrypted chain structures to verify and store data, employs distributed node consensus algorithms to produce and update data, and utilizes automated script code (smart contracts) to program and operate data [14]. The technology has evolved from Blockchain 1.0, represented by digital currencies, to Blockchain 2.0 with smart contracts like Ethereum, and now to the era of large-scale society represented by DAO and DAC, demonstrating broad application prospects. Against this backdrop, scholars have begun theoretical and practical research on "blockchain + libraries."

D. E. Frederick [15] argues that while blockchain cannot change the circulation speed of library physical collections, it can accelerate interlibrary loan and

document delivery processes. Blockchain can reduce false, malicious, and erroneous data, effectively ensuring information quality provided by libraries, and has applications in various stages of publishing peer review. M. B. Hoy [16] proposes that blockchain can be used to store tamper-proof information resources in libraries, establish metadata systems to strengthen links between libraries, and shows great potential in digital rights management. Zhang Zhonglin and Wang Ling [17] analyze blockchain application scenarios in libraries from the perspective of technology characteristics and library business needs, proposing applications in information sharing, copyright protection, identity authentication, resource storage, and network crowdfunding. Bao Yuanfang and Wang Tao [18] analyze blockchain applications in university library document resource construction and storage. Yang Qun, Zhang Ni, and Mo Zaifeng [19] present a framework for library smart microservices based on blockchain technology.

2.3 Blockchain Technology in Library Precision Services

As blockchain technology has been widely applied and studied, scholars have begun exploring how to effectively enhance library precision information service levels under blockchain architecture. Liu Yiming and Wang Jiajia [20] argue that public libraries can achieve precise identification, precise matching of cultural resources, precise management of poverty alleviation projects, and precise assessment of poverty alleviation effectiveness in cultural precision poverty alleviation through blockchain technology. Zhang Xiaoxin [21] proposes improving trust relationships between libraries and users based on blockchain technology, establishing effective dynamic links between subject service objects and libraries, and constructing a precision subject service model.

2.4 Application Scenarios of Blockchain Technology

Blockchain technology has been implemented in multiple fields, providing reference for the future development of "blockchain + libraries." For instance, China Life Property & Casualty Insurance has adopted blockchain technology throughout its poverty alleviation insurance projects, effectively improving operational efficiency and ensuring project credibility [22]. The Blockchain Service Network (BSN) has created tailored blockchain ecosystems, with provincial blockchain backbone networks completed or officially launched in Beijing, Hebei, Hubei, Zhejiang, and Fujian, demonstrating that blockchain technology will empower China' s digital economy development and social governance construction [23]. These industry applications provide valuable experience for the future development of blockchain in libraries.

3. University Library Precision Information Services

3.1 Service Process

With the rapid development of information technology and transformation of service models, libraries have evolved from simply connecting people to resources

to providing deep knowledge services that fully utilize resources. Under the background of big data integration, university libraries continuously innovate service models oriented by user demand, gradually moving toward precision information services. The specific service process involves: (1) analyzing reader information needs based on various library data resources (collection resources and user behavior data), and providing literature resource services and personalized customization according to reader information demand characteristics; (2) conducting resource management construction and professional talent training based on reader information needs to ensure service quality; and (3) regularly evaluating information service effectiveness and professional personnel to provide a basis for future service model innovation and talent development.

3.2 Existing Problems

Despite improvements in precision information services driven by big data, artificial intelligence, and cloud computing, university libraries still face several issues that need resolution, particularly as emerging and interdisciplinary disciplines develop rapidly and reader information needs become more complex and personalized.

3.2.1 Limited and Monolithic Underlying Data Currently, the identification of precision service users in university libraries is mostly based on data analysis of information controlled by the library itself, without integrating research data from relevant departments such as academic schools, social science offices, science and technology offices, and academic affairs departments. This lack of multi-angle, comprehensive aggregation and analysis of reader information needs results in missed readers and reduced accuracy in identifying information-demanding users during the precision identification process.

3.2.2 Resource "Precision" and User "Accuracy" Require Improvement Precision in services applies to resources, while accuracy applies to users. University libraries possess rich information resources that form the foundation of services. However, keyword-based literature retrieval methods can no longer satisfy current users who primarily engage in mobile and fragmented learning. Resource precision must shift toward higher-quality "information granularity" services. User accuracy requires analysis based on user data, collecting both static and dynamic reader information data, and using prediction algorithms to uncover potential information needs. Currently, university libraries' analysis of reader information behavior data remains at the level of simple classification and quantitative management, lacking deep data mining and analysis.

3.2.3 Information Asymmetry with Functional Departments and Schools Precision knowledge services constitute important content in university library support for teaching and research. However, poor communication channels exist between university functional departments or schools regarding their respective service content and needs, leading to information asymmetry. For example, many deep-level information services provided by libraries

are not well understood by other functional departments or schools, while libraries cannot accurately grasp the timing of information needs in users' teaching and research processes. This information asymmetry prevents effective implementation of library precision information services.

4. Necessity and Feasibility of Applying Blockchain Technology to University Library Precision Services

4.1 Necessity of Blockchain Application

Introducing blockchain technology to improve university library precision information services primarily addresses two aspects: First, blockchain' s data sharing technology can effectively enhance user identification accuracy. Current user identification relies on low-dimensional analysis of user basic data from library systems. Enriching user data resources requires obtaining relevant departmental user data through certain workflows, a time-consuming and labor-intensive process that significantly reduces the timeliness of user identification. Through blockchain technology, nodes on the chain can achieve real-time data sharing based on technical trust, enabling rapid and accurate user identification and providing valuable literature resource services for users. Second, blockchain' s network trust technology and traceability technology can ensure data security at each node and alleviate users' concerns about privacy and research data security. Think tank services constitute important content in university library precision knowledge services. However, scholars have long held concerns about research data security and copyright issues, resulting in slow progress in university institutional repository construction and hindering library think tank services. Blockchain technology can address users' information security concerns without requiring further data auditing, making the academic ecosystem more trustworthy. Meanwhile, precision subject services will also develop toward think tank decision-making. In summary, blockchain technology can provide implementation paths for university library precision information services from a technical perspective.

4.2 Feasibility of Blockchain Application

4.2.1 Feasibility of Multi-Technology Fusion Application Big data, artificial intelligence, cloud storage, and blockchain technologies have numerous applications in many fields. Although blockchain technology has limited application in university library precision information services, big data and artificial intelligence have some applications in university library information services. As a foundational underlying technology, blockchain can promote the integrated application and collaborative development of other emerging technologies, fully leveraging the value of data resources to meet the high-quality data requirements of university library precision information services.

4.2.2 Feasibility of Achieving Cross-Departmental and Cross-Institutional Collaboration Although university schools, functional

departments, and research institutions have sharing mechanisms in integrated office automation systems, the accuracy and sharing degree of information content vary across departments, lacking effective collaborative mechanisms. Consequently, shared data resources cannot be verified or identified, making authenticity difficult to judge. *The Economist* defines blockchain as a "trust machine," and the successful application of blockchain technology in Bitcoin sufficiently demonstrates that its network trust technology is secure and reliable. Blockchain' s decentralization, immutability, and traceability features can ensure that information data is trusted, mutually used, and collaboratively developed among departments and institutions under technically secure environments. This provides multi-level and multi-angle big data for university library precision information services while achieving precise matching between information service categories and readers or institutions.

4.2.3 Improving the University Library Precision Information Service Framework The original precision information service framework primarily controlled precision through analysis of user behavior data. Integrating blockchain technology can solve the information silo problem between libraries and readers, enhancing information service levels by obtaining more valuable data resources (research data, academic exchange data, etc.), gradually transforming information service librarians into research partners. Additionally, blockchain' s traceability can evaluate the effectiveness of precision information services, providing important references for further improving information service quality and continuously upgrading the university library precision information service framework.

5. "Blockchain +"University Library Precision Information Services

5.1 Leveraging Blockchain' s Decentralization to Construct a Library Precision Information Service Blockchain Alliance System for Accurate User Identification

Accurately identifying service objects and their service needs constitutes the first and most critical step in library service work. Only with precise identification can subsequent information services achieve high quality, high levels, and high satisfaction. Identifying service objects and needs in university libraries primarily includes readers' identity information, discipline information, research information, and other multi-dimensional content. Blockchain decentralization means that each node within the system can become a system center, establishing a decentralized precision identification system that treats school functional departments, schools, libraries, and readers all as identification subjects. The library precision information service blockchain alliance is formed by different levels within the university (see Figure 1 [Figure 1: see original paper]), with each component providing implicit information needs of readers at different levels for library precision services. Library big data contains large amounts of

explicit reader information (such as basic identity information: education level, school major, borrowing records, etc.) and implicit information (such as user profiling analysis based on library big data). Functional departments like the Personnel Office possess complete faculty education and training data, providing the most effective data for identifying deep-level information service objects; the Social Science Office and Science and Technology Office, as collectors of university research project data, can provide the most comprehensive data for library precision information services; the Discipline Construction and Planning Office, as an important department for university discipline construction planning and development, masters data on university advantageous and potential disciplines (such as ESI discipline data, A+ discipline data from undergraduate teaching evaluations), pointing the direction for library precision subject services; the Graduate School possesses comprehensive information on doctoral and master' s student training plans and progress, providing accurate timing and content for library precision learning support services (such as thesis proposal services, thesis writing services) to align with graduate training schedules. As the core of the university and key to connotative development, schools' characteristic majors, newly established majors, and national or provincial key laboratories provide multi-angle and multi-level auxiliary information for library precision services. Readers, as the library' s direct service objects, can select from library service types and content according to their needs and propose personalized information service requirements based on their own demands. The construction of a university library precision service blockchain alliance achieves decentralization, obtaining multi-dimensional reader data through multiple nodes on the alliance chain to provide information assurance for accurate identification of library service objects.

5.2 Leveraging Blockchain' s Information Symmetry with xAPI to Establish a Blockchain-Based Library Information Service Storage Platform for Service Optimization

The key to library precision services lies in providing readers with truly needed information services. With the popularization of electronic mobile devices and rapid information technology development, people' s reading behaviors and learning methods increasingly exhibit mobile and fragmented characteristics. Libraries must collect big data generated by readers' reading and learning behaviors, analyze this data based on library resources and service capabilities to enhance information service levels, and use blockchain technology to achieve perfect matching between services and needs to better satisfy readers' information demands.

xAPI is a technical specification for storing and accessing learning experiences. The organic integration of blockchain technology and xAPI enables xAPI to provide a new data recording and tracking mechanism. Blockchain is a distributed database technology with efficient data storage performance, index structures, and distributed storage optimization technologies [20], which can record and

store various processes of readers directly or indirectly using library services, both online and offline. Simultaneously, the massive information in blockchain databases can automatically filter and associate information, forming rationality, symmetry, and matching between data [24].

Integrating xAPI technical specifications with blockchain' s information symmetry features to construct a blockchain-based library information service storage platform (see Figure 2 [Figure 2: see original paper]) can better optimize library precision information services. This platform consists of five components—reader data collection, reader data analysis, reader profiling, library information service supply chain, and reader demand chain—forming a closed-loop, self-adaptive information service storage platform. First, xAPI collects and organizes data on library usage and resource utilization. Second, the data is tagged from multiple dimensional features including basic information (name, grade, discipline, major, etc.), library usage behavior preferences, and resource utilization preferences to conduct reader profiling analysis. Based on reader profiles, the platform uncovers readers' potential information needs in professional learning, research projects, and resource usage to innovate library service methods that better meet reader demands. Third, library information services provided based on xAPI reader profiling are stored as chain-structured data in distributed blocks, forming a library information service supply chain. Simultaneously, the platform can record each reader' s library information service demands using blockchain technology, forming a library information service demand chain. Blockchain technology can fully leverage information symmetry to achieve precise matching between supply and demand, matching the most suitable library information services to readers on the demand chain. Finally, reader demands from the demand chain are analyzed and tagged together with big data on readers' utilization of library information services collected by xAPI, forming a closed-loop, self-adaptive information service storage platform that ensures optimal allocation of library information service resources.

5.3 Leveraging Blockchain' s Traceability to Establish a Library Precision Information Service Traceability System for Maximizing Service Benefits

Information services constitute a key element for the long-term development of university libraries. Library precision services are deep information services oriented by user needs and based on literature resources. If university library precision information services do not positively correlate with reader satisfaction, problems exist in service content, methods, or types. While improving and refining university library precision information services, technical means can monitor the relationship between precision information services and reader information needs to ensure maximum service benefits. Blockchain's traceability can provide strong technical support for reasonable improvements to university library precision information services by enabling full traceability of user big data, ensuring that precision information service improvements are based on

objective user data and maximizing the benefits of university library precision information services.

University libraries can objectively record tagged information service content and types on the blockchain with timestamps in chronological order to ensure objective authenticity of precision information service situations. Under the blockchain framework, libraries can timely understand the relationship between precision information service provision and reader satisfaction, enabling real-time adjustment of service content, types, and methods to improve service levels. Each completed service is timestamped on the blockchain, establishing a traceability mechanism for university library precision information services that facilitates analysis of adjustment directions and avoids detours in service improvement.

5.4 Leveraging Blockchain' s Cryptographic Advantages to Establish Institutional Repository Data Sharing Services for Enhanced Think Tank Service Levels

Current academic research has shown a trend toward cross-disciplinary integration. Universities are important research institutions, and institutional repositories can comprehensively collect, systematically organize, and analyze academic achievements. Meanwhile, university library subject librarians can conduct in-depth mining of stored research achievements and provide professional, personalized knowledge services from multiple dimensions. Therefore, institutional repositories are not only platforms for managing university research achievements but also important platforms for subject librarians to deeply engage with users and provide precision subject services based on personalized needs. Disciplines are fundamental elements of modern universities, and discipline construction is central to modern university development. Library think tank services can provide strategic decision-making suggestions for discipline construction development. University library subject services can fully utilize institutional repository resource advantages to explore deep-level discipline knowledge services, optimize think tank functions of institutional repositories, and provide decision support for university discipline construction and development, thereby enhancing library think tank service levels.

In the era of big data, privacy protection issues in university library personalized services represent a "pain point" for developing diversified and personalized services. Blockchain technology' s encryption mechanisms can encrypt storage and transaction transmission to ensure data security. Meanwhile, through data isolation mechanisms that only transmit consensus-required information to consensus nodes and decrypt during output, consensus is achieved when decrypted results match outputs from data encrypted using the same method [25] (homomorphic encryption technology). This enables data stored in institutional repositories to be shared within certain permission scopes. Blockchain technology can alleviate institutional repository users' concerns about personal privacy and research achievement data security, enabling full sharing of research achieve-

ment data. Simultaneously, blockchain' s traceability can trace copyright ownership of any research achievement, ensuring proper protection of intellectual property rights and providing better intellectual property protection for institutional repository users. This creates a path for precision knowledge services in university library institutional repositories and significantly enhances library think tank service levels.

Blockchain technology has been widely applied in finance, healthcare, public affairs, education, culture, and other fields, providing reference and lessons for university library precision information services. The application of blockchain technology in precision information services will become inevitable. Meanwhile, changing reader information needs continuously drive innovation in library precision information service models. The rational application of blockchain technology enables university libraries to effectively integrate multi-departmental information within universities and achieve win-win outcomes for all parties during precision information service processes.

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Author Contributions:
Zhao Lina: Designed the overall research framework and wrote the paper;
Xu Shihe: Conceptualized the paper' s approach and research direction, and revised the paper.

Note: Figure translations are in progress. See original paper for figures.