Organization and Reuse of Open Resources

Authors: Huang Jinxia, Huang Jinxia

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Abstract

[Purpose] Taking the construction of the GoOA integrated service platform for open access journals (OA journals) as an opportunity, this study conducts research and practice on the organization and utilization of open resources in libraries.

[Method] This paper analyzes the development of open resources in terms of quantity, impact, technical specifications, and degree of openness, investigates five models for organizing and reusing open resources and their characteristics, and proposes construction ideas for open resource content organization systems and service systems by combining theoretical research and practical construction of GoOA.

[Result] By adopting universal metadata exchange specifications, parsing different digital objects in paper content and indexing them using domain ontology concepts, GoOA provides integrated discovery and full-text access to high-quality OA journal content, offers OA journal submission analysis, OA journal evaluation and assessment, and data customization services, thereby achieving sustainable integrated organization methods and distinctive reuse services for OA journals.

[Conclusion] Research on the organization and reuse of open resources will bring transformative thinking to current library resource construction work, and GoOA' s practices in content system construction and service system construction will provide reference for library open resource construction efforts.

Full Text

Preamble

Information Organization and Re-use on Open Resources

Huang Jinxi, Wang Fang, Zhang Jianyong, Chen Xuefei
National Science Library, Chinese Academy of Sciences, Beijing, 100190

Abstract

[**Purpose**] This study leverages the development of GoOA, an integrated service platform for Open Access (OA) journals, to investigate and implement the organization and utilization of open resources in libraries. [**Method**] We analyze the evolution of open resources in terms of quantity, impact, technical specifications, and degree of openness; examine five distinct models for organizing and reusing open resources and their characteristics; and propose frameworks for constructing content organization and service systems for open resources, grounded in theoretical research and practical development of GoOA. [**Result**] By adopting universal metadata exchange standards, parsing various digital objects within article content, and employing domain ontology concepts for indexing, GoOA provides integrated discovery and full-text access to high-quality OA journal content, along with services for OA journal submission analysis, evaluation and assessment, and data customization, thereby achieving sustainable integration and distinctive reuse services for OA journals. [**Conclusion**] Research on the organization and reuse of open resources will inspire transformative thinking in current library resource development practices, and GoOA' s practical experience in building its content and service systems can serve as a valuable reference for libraries undertaking open resource development initiatives.

Keywords: Open Resources, Organization and Re-use Models, GoOA, Content System and Service System
Classification Number: G250

Introduction

With the rapid development of network technologies, an increasing volume of information resources is being released through open access, facilitating knowledge dissemination and academic exchange. Government and funding agency support has further propelled the open access movement, leading to rapid growth in open resources that are gradually becoming a mainstream component of academic resources [1-2]. These resources encompass OA journals, open libraries, open dissertations, open courseware, and more. Many libraries worldwide are actively incorporating open resources to enrich their virtual collections—for instance, Harvard and Peking University libraries provide numerous links to open resources on their websites. However, these resources remain isolated rather than integrated into libraries' unified digital resource discovery systems, preventing them from leveraging the inherent openness and reusability characteristics that define them from inception [3].

Unlocking the reuse potential of open resource content is particularly crucial for libraries, as they have traditionally held only usage rights rather than ownership rights over subscribed electronic resources, limiting their capacity to provide deeper content discovery or data mining services in the big data era. As open resources proliferate and users demand more sophisticated services, libraries must consider transforming their resource development and service models, and

engage in thorough theoretical research and practical exploration of open resource development approaches, organization methods, and reuse capabilities [4]. In May 2014, the Chinese Academy of Sciences issued its open access policy [5], followed by guidelines supporting open publishing in October [6]. In this context, recommending high-quality OA journals to researchers and developing OA journal utilization services became both necessary and urgent, providing the impetus for this research on open resource organization and utilization, using the development of the GoOA (Go to Selected OA Journals) platform as a practical case study. This paper first analyzes the current state of open resource development and its primary organization and utilization models, then proposes approaches and methods for libraries to develop open resource initiatives based on GoOA' s construction experience.

2.2 Recent Developments in Open Resources (2015-2016)

During 2015-2016, the open access movement continued to drive the opening, sharing, and use of information resources. More countries, organizations, and institutions introduced open access policies, collaboration among different agencies, projects, and systems intensified, and increasingly diverse types and volumes of information resources moved toward open access, revealing four key trends:

First, the types and quantities of open resources continued to grow. Over a two-and-a-half-year period, the Directory of Open Access Journals (DOAJ) added more than 1,600 OA journals (a 16% increase), while PubMed Central (PMC) added 1.1 million articles (a 100% increase). However, some individual open resource systems experienced resource reductions—for example, MIT OpenCourseWare decreased by 35 courses within six months, and OpenDOAR recorded 40 fewer open repositories during the same period (Table 1). Since many open resources are born-digital and thus vulnerable to disappearance, preservation efforts are essential.

Second, open resources are gaining increasing influence, and scholars are growing more confident in their quality. The Directory of Open Access Books (DOAB) received the 2015 IFLA/Brill Open Access Award. The Scholarly Publishing and Academic Resources Coalition (SPARC), together with over 85 educational institutions, libraries, technology departments, and public interest and legal organizations, called on the White House to adopt administrative measures ensuring that federally funded educational materials can be freely used, shared, and improved as Open Educational Resources (OER) [10]. A survey of 22,000 researchers conducted by Nature Publishing Group and Macmillan Publishers in August 2015 indicated growing confidence in OA publishing quality: whereas 40% of scientists expressed concerns about OA publication quality in 2014, this figure dropped to 27% in 2015 [11]. Continued efforts to improve open resource quality and academic impact are necessary to ensure sustainable development based on recognized credibility.

Third, technical specifications for open access have been strengthened. In 2015, DOAJ updated its journal metadata schema, increasing data attributes from 17 to 54. The Confederation of Open Access Repositories (COAR) launched a vocabulary editing draft for open repository resource types. OpenAIRE introduced new guidelines for Current Research Information Systems (CRIS), establishing interoperability specifications between CRIS and OpenAIRE to ensure information exchange based on the CERIF data model, CERIF XML exchange format, and OAI-PMH protocol [12]. For scattered open resources, broad discoverability, sharing, and usage are crucial prerequisites for quality recognition and enhanced academic impact, making technical standardization and sharing mechanisms essential for widespread dissemination.

Fourth, open resources have increased their degree of openness, yet usage constraints persist. BMC and Hindawi publish all OA journals under CC BY licenses, and Nature Publishing Group' s OA journals adopted CC BY 4.0 as the default license in 2015, with some OA journals applying CC0 licenses to associated open data. Even when authors provide Creative Commons licenses for resource use, disputes over usage rights—including copyright and licensing issues —still arise relative to users' expectations of unrestricted "open" and "access" [13]. Some OA journal articles' copyrights remain held by publishers, preventing widespread sharing and dissemination. The licensing issue primarily involves resources being used improperly despite having defined Creative Commons license terms under OA. Balancing the rights among authors, publishers, and users represents a significant challenge for open resource reuse.

3 Analysis of Typical Models for Open Resource Organization and Re-use

Open resource information organization methods include metadata-based resource discovery, content-based information integration or linking, and knowledge graphs based on data/knowledge concepts—approaches no different from those for non-open resources. Open resource reuse refers to uses beyond traditional "open access" activities such as reading, downloading, copying, distributing, printing, searching, and linking to full-text articles. These extended uses include building indexes for open discovery systems, serving as batch open data for software processing, and being reformatted or semantically processed as new open data for republication—capabilities not available for non-open resources.

3.1 Models for Open Resource Organization and Re-use

Current policies and technologies provide a foundation for open resource reuse: policies governing open data usage rules under varying degrees, methods, and purposes, along with protections for competition, privacy, and public welfare, are continually being proposed and refined to support reuse. Networked and digitized open information features structured, machine-readable formats that enable computational parsing and processing. Fine-grained annotation of knowl-

edge objects and their relationships within open content facilitates mining and computation of relationships among digital objects. Linked open data provides a technical framework supporting semantic linking among multi-source, heterogeneous data [14].

In addition to models described by Huang Yongwen et al. [15], the big data era' s demand for data mining and analysis has given rise to data-level organization and reuse models. This paper summarizes five such models:

Model 1: Thematic Aggregation Services for Open Information. Targeting specific disciplines or topics, these services establish evaluation criteria to select compliant resources from open repositories or publications, organize them, and release them periodically according to publication schedules. The ECO4R project exemplifies this approach, aiming to discover, reuse, and preserve compound digital objects related to publications (e.g., videos, data tables, software) from numerous repositories. The project first constructed an OAI-ORE resource graph, then utilized this graph and resource discovery plugins to dynamically identify and aggregate compound digital objects from repositories, presenting them as a virtual thematic journal that enables data reuse in any network environment [16].

Model 2: Integrated Retrieval and Open Services for Open Resources. By establishing local indexes of open resource metadata and even full text, these services integrate multi-source open resources to provide discovery and access services, while offering standard APIs for third-party system integration. Examples include DOAJ, BASE, and PMC. BASE (Bielefeld Academic Search Engine) from Bielefeld University integrates diverse document types including books, articles, reports, dissertations, reviews, audio, video, images, maps, software, and raw data, totaling over 90 million documents. While approximately 36% of BASE' s resources are OA, 4% are non-OA and 61% have unclear copyright status [17]. DOAJ serves as an integrated directory of OA journals, providing metadata-based search for 70% of OA journal articles and linking to source URLs, with local storage for some journal articles.

Model 3: Content Linking of Multi-type Open Resources and Citation-based Analytical Networks. Based on local system development needs, this model achieves content connections with other relevant resource systems, such as linking articles with related raw data, charts, videos, and other digital materials. The integration project between Harvard University' s Dataverse Network and the Open Journal Systems (OJS) platform ensures permanent bidirectional linking between articles and data through interoperability between OA journal systems and data repositories [18]. By linking large volumes of open publications, this model constructs open scholarly resource citation analysis networks to identify high-impact articles, analyze research group behavior patterns, and distill research field development trends, as exemplified by DOARCS (Distributed Open Access Reference Citations). DOARCS creates interactive citation metrics for scientific literature, particularly OA documents in German university and research institution repositories, with the

innovative feature of providing value-added services based on citations to open resources, such as discovering citation networks [19].

Model 4: Semantic Data Publication and Reuse of Open Resources. This model involves more granular structuring and semantic enrichment of open resources, republishing the enriched data for open use by other applications. Examples include BioLit and OpenAIRE Plus. OpenAIRE Plus invests significant effort in data enrichment, automatically inferring semantic relationships among entities such as articles, datasets, authors, subjects, and funders to compensate for the lack of entity relationships in integrated data, thereby providing richer contextual information. OpenAIRE Plus offers five-star open linked data through a SPARQL endpoint [20].

Model 5: Knowledge Discovery through Rich Open Datasets. DataStaR, developed by Cornell University Library, provides high-quality open linked data for scholars'repeated use while performing data curation services. In ecological research, for example, scholars submit field observation data to DataStaR, which generates semantically linked data according to the Vivo ontology model. As datasets continuously enrich, the system ultimately generates geographic information systems (GIS) displaying species distribution [21]. Theodore Dalamagas et al. used miRBase as a case study to explore organizing and publishing life science data as linked open data. MiRBase is a searchable database storing published miRNA sequences and annotations, and Dalamagas' s linked data server assists biologists in exploring biological entities and development while providing SPARQL endpoint applications for historical queries of miRNA data, mutation tracking, and causality investigation [22].

3.2 Characteristics of Open Resource Organization and Re-use

The digitization and opening of resources are transcending purely reading-oriented information concepts. Technologies such as semantic enhanced publishing and ontology-based data generation support parsing and annotation of various knowledge objects and their relationships in scientific literature, readily forming linked, semantic, networked datasets for aggregation, republication, citation evaluation, and data mining.

Currently, open resource organization and reuse primarily focus on metadata-level linking and content-level association and discovery, with data-level organization and reuse limited to open scientific data resources. STM' s 2015 technology trends report posited that data would become the most important research material, with articles serving as a key axis within the data environment alongside non-textual and multimedia resources to support user needs [23]. Future information resource development will move toward data-level organization and utilization, with open resources becoming a significant data resource due to their diversity and volume, enabling full exploitation.

The integration, use, reuse, and preservation of open resources are closely related to the technical specifications and usage constraints of relevant resources

or systems. This has resulted in current organization and reuse efforts primarily utilizing resources from the builders' own collections, such as institutional repository articles and data repository datasets. Only by fully understanding and resolving rights relationships among stakeholders can libraries leverage widely distributed open resources and achieve deeper levels of reuse.

4 Practice in Open Resource Organization and Re-use: GoOA Development

Open resources have become a crucial component of library collections beyond commercial resource procurement. Effective integration and service of open resources may drive transformation in library resource development and secure a position in the future OA movement. The primary tasks involve constructing efficient methods for open resource organization and reuse to substantially advance content and service development.

4.1 GoOA Development Background

Joint statistics from DOAJ, Ulrich' s, and PMC indicate that the number of OA journals exceeded 12,000 in 2015. Several OA journal integration platforms have emerged, including DOAJ, J-Stage, Paperity, and PMC internationally, and Socolar domestically, providing one-stop access and retrieval services. However, phenomena such as "integration without selection," "integration without organization," and "non-open open platforms" have hindered service effectiveness and impeded user recognition of high-quality OA journals.

The National Science Library of the Chinese Academy of Sciences began developing the GoOA (Go to Selected OA Journals) platform in 2013. This initiative addresses key issues in open resource development, including frameworks and workflows, evaluation systems, discovery and access constraints, reuse models, rights management, and linking between OA journal articles and scientific data. Concurrently, GoOA constructs content and service systems encompassing journals, articles, data, and concepts at different levels, offering one-stop discovery and access, submission analysis, evaluation and assessment, data services, customization, and dynamic tracking of open resources (Figure 1 [Figure 1: see original paper]). Currently, GoOA is collected by over 100 institutions worldwide, recorded more than 100,000 visits in 2015, and established data partnerships with numerous publishers.

4.2 GoOA Information Organization and Data Organization Methods

Based on OA journal development characteristics and analysis of open resource organization and reuse models, GoOA prioritized information organization and service design from its inception, ultimately developing seven distinctive features (Figure 2 [Figure 2: see original paper]).

Phase 1: Resource-based Information Organization (OA Journals and

Articles). GoOA conducts annual evaluation and selection of global OA journals, collecting 1,955 OA journals and 270,000 OA articles in 2015. To enable one-stop discovery and access, GoOA employs multiple information organization methods: (1) Adopting the JATS (Journal Article Tag Suite) standard —a universal metadata exchange format for journal full-text documents and archives—defining elements and attributes describing journal and article features such as licensing, archiving policies, impact factors, submission guidelines, and share counts, with specific provisions for figures, tables, open research data, and supplementary materials. The JATS tag set comprises over 200 elements and 130 attributes. (2) Developing an OA journal disciplinary classification system by integrating subject navigation schemes from DOAJ, Springer, and Elsevier databases, establishing 18 first-level disciplines and 181 second-level disciplines with finer granularity for rapidly developing fields. (3) Aggregating monthly hot articles and latest articles by Chinese Academy of Sciences authors based on user access and download statistics. (4) Embedding multiple domain ontologies (e.g., astronomy, botany, physics, gene ontologies) to conceptually index article titles, keywords, abstracts, figures, tables, and open data, enabling domain knowledge concept navigation, retrieval, and expanded searching based on related concepts. For example, browsing "gene expression" under "hot concepts" prompts the system to recommend 上位 and related concepts from the ontology (e.g., "amylopectin metabolic process," "macromolecule modification") while performing term frequency statistics on concepts indexed in search results to identify high-frequency terms like "DNA methylation," "immune response," and "aging," supporting expanded and precise retrieval.

Phase 2: Content-oriented Open Data Organization. During GoOA' s information service provision, researchers' needs have transformed the platform toward data-centric organization and utilization. For instance, rice researchers hope to mine data on rice varieties, genotypes, disease-resistant phenotypes, primers, and PCR electrophoresis images "hidden" in article sections such as "Materials and Methods" and "Results." (1) GoOA redesigned its data metadata schema based on Dryad and DataCite formats to establish linkages between data and other literature types. (2) When acquiring and storing OA articles, GoOA parses various digital objects including authors, institutions, abstracts, keywords, licenses, figures, tables, open data, and references, using ontology concepts for indexing. Platform content is reorganized based on this data to enable discovery of figures, tables, and open data, along with related data and source articles. (3) GoOA integrates data from Dryad and other OA journal data storage systems through open APIs, establishing linkages with GoOA articles. This version is currently being deployed.

4.3 GoOA Service System Centered on Open Resource Development

Based on GoOA' s research on key open resource development issues and practical experience with integration and service models, GoOA has implemented a multi-audience service system:

For Users: (1) The Chinese/English GoOA platform collected 1,955 high-quality OA journals in 2015, providing one-stop discovery and access to OA journals and articles. (2) Users can more easily discover figures, tables, and open research data sourced from OA articles. (3) Domain ontology-based conceptual indexing enables more precise article discovery and expanded conceptual retrieval. (4) Trend analysis is provided for search results, including high-frequency keywords, top author collaboration networks, and keyword co-occurrence networks. (5) GoOA offers open API services for OA journal and article metadata, allowing individual users to obtain customized data and system users to integrate interface data. (6) The GoOA team continuously monitors rights issues in open resource acquisition, services, and preservation, developing rights management solutions to provide rights management services for system users integrating and using open resources.

For Authors: (1) Based on GoOA' s rigorous OA journal selection and evaluation criteria [24], the platform provides submission analysis information including impact factors, indexing status, archiving policies, submission guidelines, and APC (article processing charges). GoOA released annual OA journal rankings in 2014 and 2015, supporting authors and users in better understanding and utilizing OA journals. (2) The GoOA team provides analytical reports on the academic impact of OA articles across different fields, comparing citation counts between OA and non-OA articles to help authors decide whether to publish OA [25].

For Librarians: (1) As an open resource, GoOA allows libraries to collect it and provides code to help librarians embed GoOA links into library websites. (2) The GoOA team developed Chinese/English "Open Resources Development Guide"websites for reference by open resource development initiatives worldwide [26]. (3) The GoOA team tracks international OA and open resource developments, monthly publishing "Open Resources Development NEWS"covering over 200 libraries, intelligence agencies, and publishers.

5 Approaches and Methods for Library Open Resource Development and Services

Beyond GoOA, the National Science Library of the Chinese Academy of Sciences has developed collection service systems for open conference resources, open courseware, and open socioeconomic information. The current collection comprises over 1,955 OA journals, 50,000 open courseware items, 70,000 open conference papers, and 50,000 open socioeconomic information records, forming a comprehensive open resource system.

Based on research and practice in open resource development, we propose the following approaches for peer exchange:

First, open resource development should adopt a systematic engineering approach, holistically considering needs assessment, key issue research, system

construction, and service capacity building. Libraries should designate dedicated open resource development librarians to perform comprehensive workflows including resource discovery, evaluation, selection, acquisition (through collection and data partnerships), processing, storage, organization, service provision, and rights analysis throughout the development lifecycle. While greater openness and technical standardization reduce development costs, libraries must still conduct thorough evaluation and selection to meet user quality and impact expectations, analyze and manage rights issues to ensure reasonable content reuse, and implement open storage to guarantee service sustainability and broader dissemination.

Second, the U.S. National Science Foundation' s "Cyberinfrastructure Vision for 21st Century Discovery" report explicitly states that "in the future, America' s international leadership in science and engineering will depend increasingly on our advantage in digital scientific data and on our ability to transform that data into information and knowledge through sophisticated data mining, integration, analysis, and visualization tools" [27]. When developing open resources, libraries must move beyond simple discovery to achieve data-level organization and utilization, enabling storage of more data resources to provide effective data services for scientific research in the big data environment. While building collection service systems proves somewhat effective for acquiring and organizing open resources, certain resources like research data remain challenging due to their complex types and formats, large volumes, scattered distribution, and researchers'reluctance to share. GoOA's approach involves collaborating with researchers who have data acquisition and analysis needs, targeting required data for collection, organization, and utilization before integrating it. This process may represent an opportunity for transforming library resource development methods.

Third, strengthen broader collaboration. The 2015 merger of Nature Publishing Group and Springer created the world' s largest and likely strongest scientific publisher, further advancing OA journals. DOAB' s partnership with SciELO added 300 OA books. The U.S. National Institute of Standards and Technology (NIST) released a public access plan collaborating with NIH to use the PMC platform for open access to articles and data from NIST-funded research. Open resource development, acquisition, and services require collaboration with multiple OA movement stakeholders, including researchers (as authors and users), OA publishers, OA funding agencies, and OA policy institutions. The National Science Library's assistance in drafting the Chinese Academy of Sciences OA policy, funding CAS researchers to publish OA articles, and GoOA' s partnerships with OA publishers for integrated article sharing have all achieved positive results. The ultimate goal of library open resource development extends beyond merely increasing collections to positioning libraries strategically as the OA movement continues to evolve.

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Author Contributions: Huang Jinxi: responsible for article writing and GoOA team leadership; Wang Fang: responsible for GoOA data organization development and service model design; Zhang Jianyong: proposed open resource

development approaches and methods; Chen Xuefei: responsible for open resource evaluation, GoOA ranking reports, and service model design.

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