

Development Strategy and Implications of the German National Library of Science and Technology: Postprint of a Seminar on the Feasibility of Implementing a Product-Driven Development Strategy

Authors: Kong Yuan, Gu Liping

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Abstract

[Purpose / Significance] The strategic significance of data-driven research has become evident in the development plans of multiple countries, and the library community has consistently called for exploring specific approaches and practical methods for managing research data. By examining the practice of the German National Library of Science and Technology (TIB) in implementing its development strategy through product lines, this study aims to provide reference and inspiration.

[Method / Process] Through literature research and case analysis, and following the hierarchical logic of “strategic level–tactical level–operational level,” this study investigates and analyzes the development practices of the German National Library of Science and Technology, with a focus on uncovering the distinctive features of its four major tactical product lines, and compares them with similar domestic services.

[Results / Conclusion] Strategic responses should be closely aligned with tactical deployment; domestic research data management should emphasize non-textual resources; project implementation and talent cultivation should mutually reinforce each other.

Full Text

Preamble

The German National Library of Science and Technology’s Development Strategy and Its Implications: A Study on the Feasibility of

Product-Driven Strategic Implementation

Kong Yuan^{1,2}, Gu Liping^{1,2}

¹National Science Library, Chinese Academy of Sciences, Beijing 100190

²School of Economics and Management, University of Chinese Academy of Sciences, Beijing 100049

Abstract

[Purpose/Significance] The strategic importance of data-driven research has become evident in national development plans across multiple countries, and the library community has consistently called for exploring specific approaches and practical methods for managing research data. By examining the German National Library of Science and Technology's (TIB) practice of implementing its development strategy through product lines, this study aims to provide valuable references and lessons.

[Method/Process] Through literature review and case study analysis, and following the hierarchical logic of "strategy-tactics-operations," this paper investigates and analyzes TIB's developmental practices. It focuses on uncovering the distinctive features of its four tactical product lines and compares them with similar services in China.

[Result/Conclusion] Strategic responses must be tightly coupled with tactical deployment. Domestic research data management should place greater emphasis on non-textual resources, and project implementation should be mutually reinforcing with talent development.

Keywords: open science, data science, non-textual materials, visualization product, development strategy, library service

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1 Introduction

Data-driven research has gradually become a key characteristic of the fourth paradigm of science. Since the late 20th century, scientific research has shown a trend of shifting from positivism toward data science, and in the early 21st century, data-intensive research activities have accelerated. The management of digital and informatized research data has increasingly become a focus for libraries and information institutions. Many countries have recognized the potential value of research data management and have elevated it to the level of

macro-strategic planning through relevant policies and measures.

The United States explicitly deployed the strategic activity of “mining the value of research data” in its “Big Data Research and Development Strategic Plan” released in May 2016. The European Union, at its “Towards an Open Science System” conference in May 2016, clearly emphasized the “optimized reuse of research data.” China, in its “Action Outline for Promoting Big Data Development” issued in September 2015, pointed out the need to “form a big data-driven model of scientific and technological innovation.” Against this backdrop of data-driven research, exploring specific pathways and practical methods for managing research data is of significant importance. The German National Library of Science and Technology (TIB) has both a solid foundation and new project developments in this regard.

The changes brought by data-driven research to scientific activities have already impacted the service models and content of libraries and information institutions. In March 2016, Deputy Director Liu Xiwen of the National Science Library, Chinese Academy of Sciences, stated at the China Data Librarian Training Workshop that libraries need to adjust their staff training direction to address emerging research needs in the context of data science. In July of the same year, the annual conference of the Special Library Branch of the China Library Association discussed new knowledge services based on big data and value-added knowledge from both theoretical and practical perspectives. In September, Director Huang Xiangyang of the National Science Library, Chinese Academy of Sciences, delivered a report titled “Knowledge Services in Open Science” at the China Institutional Repository Conference, proposing that new knowledge value-added services oriented toward the public and big data must be vigorously developed. The domestic library community has recognized the impact of big data on research activities and is actively seeking methods and pathways to better serve researchers by managing research data.

TIB’s relevant practices offer valuable references for libraries and information institutions. By observing TIB’s practice of responding to and feeding back strategic planning through product lines, this paper aims to achieve three objectives: (1) provide a feasible method for examining excellent international practices; (2) offer insights into TIB’s meaningful practices and products; and (3) provide references for international exchanges and cooperation regarding similar products and services in domestic libraries.

Following the hierarchical logic of “strategy-tactics-operations,” this paper examines TIB’s macro-level vision planning, meso-level product development, and micro-level implementation methods. It analyzes the operational mechanism through which TIB drives tactical deployment and strategic realization via product research and development activities. Finally, by reflecting on relevant domestic practices, it provides lessons for domestic libraries to adapt to the new environment of data-driven research.

2 Observation Perspective 1: Macro-Level Strategy

This paper's observation of TIB's macro-level strategy is conducted from three aspects: (1) examining the guiding target of its strategy formulation, namely organizational positioning; (2) understanding the foundational basis of its strategy formulation, namely historical foundation; and (3) investigating the detailed content of its formulated strategy, namely current strategy.

2.1 Organizational Positioning

The German National Library of Science and Technology (Technische Informationsbibliothek, hereinafter referred to as TIB) is a national library that, as a university library affiliated with Leibniz University Hannover, also bears the responsibility of supporting national information strategy—serving researchers and their research activities nationwide. Relying on the university's disciplinary construction and research strength, TIB has proposed strategic goals that emphasize practical methods: “to provide users with innovative, effective, and unimpeded access to data, information, and knowledge, and to enable them to extend a larger information space in an appropriately structured manner.”

Around 2011, based on considerations of changes in the data environment and institutional research needs, TIB deployed a development strategy to transform into an open portal for distributed big datasets. This involved a series of initiatives, primarily realized through product development, with a focus on promoting the use and management mechanisms of permanent identifiers for research data (Digital Object Identifier, DOI).

At the micro level, TIB promoted the use of DOI within the library, systematically marking and structurally reconstructing digital resources, optimizing relevant portal websites (such as GetInfo), and extending related information value-added services. At the macro level, it achieved standardized management of research data through extensive library cooperation. In 2009, TIB jointly established DataCite with relevant institutions, using DOI to provide research communities with trustworthy services for locating, identifying, and citing research data. It supports the creation and distribution of DOI and accompanying metadata, facilitates the retrieval and discovery of research data, and promotes the dissemination and sharing of research data. It has now become a leading international institution providing DOI services, with member units widely distributed across more than 20 countries and regions.

TIB's active promotion of DOI applications laid the groundwork for its further strategic transformation. In fact, DOI can only play its key role in linking academic resources when combined with other technical products, thereby further extending product functionality. With a relatively complete DOI application mechanism as a springboard, TIB was able to continue its current strategic deployment.

2.3 Current Strategy

TIB's "Strategy 2015-2017" document centrally reflects its thinking about the contemporary environment and its own role. The plan formulated six major development priorities, with several goals and practical focuses summarized for these priorities (see Table 1). TIB's key practical development work is relatively concentrated, summarized into four aspects: metadata standard formulation, research data management, non-textual resource management, and long-term data preservation.

3 Observation Perspective 2: Tactical Deployment

In response to new knowledge demands in big data era research activities, TIB has adjusted and expanded its product research and development activities in four areas: open science, data science, non-textual materials, and visualization analysis. These four areas collaboratively promote digital/networked development.

3.1 Open Science Product Line

Open science represents the best practical approach to data-driven research. Behind data-driven research lies the need to address a series of demands and problems related to the preservation, circulation, management, and assurance of research data. The focus of TIB's Open Science Department is to promote a research collaboration environment supported by open science infrastructure.

TIB established the Open Science Lab, which maintains long-term cooperative relationships with multiple institutions providing researchers or research infrastructure, including the Leibniz Research Network 2.0.

Open Science VIVO Beta (since March 2014) utilizes linked open data to provide the research community with collaborative, consistent, and diverse information display. By timely capturing research activity and output information from major German-language research institutions and using the expansion and integration of linked data ontologies, it achieves interconnection and integration of information on research institutions, personnel, and projects across Europe. The network currently includes 597 researchers, 19 institutions, and 766 research outputs, and is widely used in European and American research communities.

CoScience (March 2014 - March 2015) is a digital information service project designed to help researchers share research methods, store research experience, and promote emerging research tools. In its two phases, the project cooperated with 13 university libraries, information institutions, and digital projects. Through open platform documentation and open video lectures, it integrated experience and methods for researchers and guided knowledge sharing among them.

3.2 Non-Textual Resources Product Line

TIB's "move beyond text" strategy has practical significance. A library's knowledge resources remain its most important capital and foundation. The advancement of the big data era has expanded library collections beyond traditional print resources to encompass broadly defined data resources with multiple data types and geographically distributed storage.

TIB's Non-Textual Materials Department focuses on various types of digital scientific and technical information. It has conducted a series of practices for collecting, indexing, accessing, and storing non-textual resources, treating them as "cultural heritage" equivalent to traditional textual resources. Below are relevant practices in three key areas: comprehensive research data, audio-visual multimedia materials, and 3D data.

RADAR (Research Data Repository) (September 2013 - August 2016) is a general-purpose research data repository established based on the Leibniz Information Infrastructure. It provides multi-dimensional research data preservation (maximum preservation period of 15 years), publication, authentication, and tracking. It integrates data with libraries, research institutions, publishers, and open platforms to achieve distributed storage and integrated access to research data.

AV-Portal (since 2014) is a distributed integration portal for audio-visual multimedia research data. Its video resources cover multiple disciplines including natural sciences and engineering, with strict quality control over video content, which mainly involves computer visualization, teaching materials, simulation, experimental processes, interviews, and conference records. When retrieving video resources, users can access video content overviews, language translation of video speech content, and frame-by-frame content retrieval. Users can freely upload resources, though publication requires review, and some resources support open access.

DURAARK (February 2013 - January 2016) is a database for the long-term preservation of 3D models in architecture. It organizes and indexes 3D model resources of buildings from the semantic level, establishing new metadata formats to preserve building data information in the form of three-dimensional models for long-term storage, aiming to achieve multi-dimensional and convenient access to building information.

3.3 Data Science Product Line

In TIB's data science product development activities, numerous achievements involve in-depth analysis and mining of data using data science as a tool. In this product development field, TIB similarly faces complex data types as processing objects. Like the non-textual resources product line, it focuses not only on traditional textual information but more importantly on retrieving, querying, and preserving various digital scientific and technical data sources such as research

data, audio-visual content, 3D information, simulation modules, and software.

Based on tools from machine learning, pattern recognition, and statistics in the data science domain, TIB has conducted semantic exploration of research data analysis, organization, and retrieval, with research results mostly applied to retrieval tools and systems.

AV-Portal represents the culmination of data science products, with applications in both of its key work areas: text (data) mining and knowledge management (semantic classification, ontologies, etc.). Text mining tools mainly organize unstructured data to make it structured and mine potential relationships within it, while knowledge management primarily improves existing collection resources at the semantic level.

The portal supports multi-dimensional data recognition for quality-controlled scientific videos, including scenes, text, speech, and images. It analyzes and processes different features of objects at different granularities to enable fast, consistent, and interactive access to information. It organizes resources semantically, expands retrieval methods, supports DOI-based citation of scientific films and segments, and enables uploading of self-made films and research auxiliary materials. Multimedia retrieval methods and semantic data analysis technologies enable better organization and retrieval of these unstructured resources.

3.4 Visualization Analysis Product Line

TIB's open science product line liberates resources, the non-textual resources product line preserves them, the data science product line mines them, and the visualization analysis product line explains them. Visualization analysis addresses problems such as uncovering hidden relationships in massive data information and presenting deeply mined conclusions to users in easily understandable forms. Visualization technology can present complex and abstract semantics hidden within information resources to readers through intuitive graphical representations.

TIB's visualization research applications focus on resource visualization display and retrieval, including intelligent display and visualization of large multimedia resources, interactive retrieval queries, and usability of contextual retrieval.

PROBADO 3D (January 2007 - December 2011) is an important branch of the PROBADO (Prototypical Operation of Common Documents) project. PROBADO primarily designs metadata formats for non-textual and multimedia data resources to facilitate scientific access. Starting with specific types of multimedia data, it explores innovative and appropriate metadata forms. Currently, there are two sets of databases based on innovative metadata, one of which is PROBADO 3D. This database provides visual storage and retrieval of 3D architectural models and offers corresponding open-source code.

VisInfo (January 2010 - December 2012) is an interactive, graphical retrieval system for research data in meteorology, earth, and climate science. Its visualiza-

tion applications mainly include two aspects: visualization of query construction (Figure 1 [Figure 1: see original paper] shows its editing query box for finding mathematical models, which allows constructing mathematical curves through hand-drawing or data uploading) and visualization of search results (such as clustering and filtering).

3.5 Synergistic Mechanism of the Four Product Lines

The four product areas developed by TIB do not represent a “parallel development” but rather a corresponding “cooperation strategy.” Different departments have different functions, and their extended practices also differ. The specific synergistic mechanism is shown in Figure 2 [Figure 2: see original paper].

The open science product line builds upon existing open access policies and intellectual property management to continuously improve infrastructure construction (promoting the free flow and sharing of information) and establish broader collaboration networks (promoting researcher exchanges and cooperation). Its purpose is to create an open environment that facilitates the free flow of research data, laying the foundation for subsequent activities to mine the value of research data.

The non-textual resources product line conducts effective collection and storage of data within the open science environment. Big data era technologies have enabled the emergence of large quantities of non-textual data resources that were previously difficult to track and capture, providing opportunities for effective collection and storage equivalent to traditional text. TIB’s non-textual resources products integrate multiple data types of non-textual research data through building disciplinary repositories and resource portals to achieve integrated storage and retrieval.

The data science product line seeks deep mining and analysis of enriched research data based on resource integration to achieve the reusability of research data. Using methods and technologies from mathematics, statistics, and computer science, it conducts semantic expansion of information organization and retrieval systems. It achieves logical structuring of research data, enabling multi-granular and multi-dimensional information access.

The first three product areas have covered the stages of research data collection, preservation, and reuse. The visualization analysis product line primarily addresses user interaction, explaining to users the value-mining process of research data products from the first three stages through intuitive and understandable graphical forms, facilitating user understanding and absorption of knowledge. Thus, the four product areas complete the entire process from scattered and discrete research data to orderly collection, stable preservation, in-depth analysis, and finally meeting specific user needs.

Although the four product areas have strategic emphases, their product boundaries are blurred, with many overlapping and intersecting specific businesses.

For specific tasks, business combinations can be made according to needs to achieve “lean production” of knowledge products. The maintenance of AV-Portal involves three departments including open science, non-textual resources, and data science, with different departments leading at different project stages. VisInfo and PROBADO are jointly promoted by the non-textual resources and visualization analysis departments.

3.6 Comparative Analysis with Domestic Practices

Through the above investigation, the specific product sets corresponding to the four product lines are shown in Table 2, along with comparisons with similar domestic services.

The core products launched by TIB’s product lines are indeed closely aligned with the various strategic priorities mentioned in its macro strategy, namely the four major aspects of metadata standards, research data management, non-textual resource management, and long-term data preservation. In contrast, similar services developed by domestic libraries mostly rely on institutional repositories to expand services in research data management and long-term data preservation.

China’s current development approach is formulated based on a comprehensive consideration of existing resource foundations and economic costs, but it has corresponding limitations in the long term. Currently, most institutional repositories built by academic libraries in China contain textual resources such as journals, papers, and reports, and the information services derived from such institutional repositories are mostly oriented toward textual information. However, the data types of the massive volume of research data are much more complex, with non-textual resources even constituting the vast majority.

TIB’s product line development, however, focuses on non-textual resources as a key point. It not only relies on existing institutional repositories (such as PROBADO) but also builds new specialized research data archives (such as RADAR) and specific resource databases (such as DURAARK), defines metadata standards for multimedia resources, establishes retrieval systems for multimedia resource databases, and promotes interactive integration of textual and non-textual data resources.

When domestic libraries deploy related service product development, they should consider the possibility of “moving beyond text.” They should think from the source of data storage to seek the most appropriate data preservation and organization methods for long-term development and service expansion.

4 Observation Perspective 3: Operational Implementation

Although TIB’s product research and development activities at the tactical level vary in content, they share one commonality in operation—talent team building is accomplished through project operations. The continuous incubation and

progress of specific projects drive the achievement of tactical-level goals, thereby realizing the institution's overall strategic objectives.

TIB's strategic transformation embodies the philosophical thinking of starting small and progressing gradually. Each project has a designated responsible team and funding agency (see Table 3). The team is responsible for planning project timelines and overall objectives, even subdividing stages and drawing roadmaps. For example, RADAR under the non-textual resources product department follows a "two-step" development strategy: building an interdisciplinary platform for storing high-quality research data, and achieving data publication based on integrated data storage. CoScience under the open science department is also conducted in two phases, with the first phase focusing on open platform documentation and the second upgrading the manual to a new interactive model, namely open video lectures. After the basic construction of the open resource portal AV-Portal was completed, it was handed over to the non-textual resources department for further development to optimize its retrieval system.

Based on this strategic development mechanism, TIB promotes positive interaction among the strategic, tactical, and operational levels. The focus is on the interactive relationship between talent and products, with the fundamental aspect being the establishment and cultivation of human resources.

As projects continue to advance, team members' capabilities and experience expand simultaneously. The enhanced competitiveness of human resources, in turn, uncovers new development potential for projects, forming a virtuous cycle at the operational level. This virtuous cycle at the operational level then drives the operation of the four product lines at the tactical level, ultimately achieving institutional objectives at the strategic level (see Figure 3 [Figure 3: see original paper]).

By entrusting new projects to designated teams, both the teams and products grow together. Mature products can serve specific tactical and strategic goals, while the developed talent and their insights formed through practical experience can more profoundly influence the institution's overall knowledge structure and cognitive capabilities, exerting a positive influence on the formulation of the institution's next-stage strategy.

5 Conclusion

By examining TIB's product-driven strategic implementation process, the following insights can be gained: (1) Strategic implementation must rely on specific tactical arrangements and operational-level practices; (2) When developing research data management products domestically, greater consideration should be given to incorporating larger volumes of non-textual resources into the construction scope, and research data management product lines should be arranged from the perspective of data storage methods; (3) The approach of having research teams responsible for specific projects enables the collaborative growth of both products and talent; (4) Only products that can support existing strategic

and tactical goals can foster the emergence of future visionary talent. When considering issues related to library construction direction and methods under new circumstances, we should emphasize practice and talent, and even more importantly, the idea of shaping talent through practice and promoting development through talent.

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Author Contributions:

Kong Yuan: Drafted the original manuscript, conducted case investigations, and revised the paper;

Gu Liping: Determined the research direction, formulated the paper framework, and guided the writing.

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

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