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Sociotechnical Paradigm in the Study of Metadata Interoperability in Digital Libraries

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General Background: Metadata interoperability is a critical foundation for the effective development and management of digital libraries, enabling extensive, open, and sustainable access to information. **Specific Background:** Existing research predominantly adopts a positivistic paradigm, emphasizing technical conformity to metadata syntax, format validity, and interoperability protocols such as OAI-PMH and Dublin Core. **Knowledge Gap:** This technical focus often neglects social, semantic, and institutional contexts, resulting in limited adaptability to diverse user needs and institutional environments. **Aims:** This study introduces the sociotechnical paradigm as an alternative framework for understanding and enhancing metadata interoperability. **Results:** Through a literature review and reference to digital library development models, the research demonstrates how the sociotechnical paradigm integrates technological systems with social dynamics, institutional policies, and localized meaning-making processes. **Novelty:** The study reframes metadata interoperability not merely as a technical process but as a collaborative, participatory, and semantic negotiation among stakeholders. **Implications:** By embedding sociotechnical principles, digital libraries can evolve as adaptive socio-information systems that reflect user contexts, embrace diversity of meaning, and strengthen inclusivity in knowledge access.

Highlights:

- Bridges technical and social dimensions of metadata.
- Promotes participatory and contextual design.
- Enhances inclusivity in digital library systems.

Keywords: Metadata Interoperability, Sociotechnical Paradigm, Digital Libraries, Semantic Context, Inclusive Access

Introduction

One of the fundamental issues in digital library management is metadata interoperability, which is the ability of systems to exchange and interpret information across platforms, domains, and institutions. This interoperability is not only technical but also an integral part of how information entities are represented, contextualized, and accessed across institutions within the digital library ecosystem. Metadata schemas such as MARC, Dublin Core, MODS, and RDF become important tools in ensuring that connectivity. However, success in building metadata interoperability is not

sufficient if it only relies on format or syntax compatibility; it must also consider the semantic, social, and epistemological aspects that accompany the information representation process [1].

1. Previous Research

Several studies have explicitly identified these challenges. Jin [2], shows that the diversity of metadata standards with varying levels of specification and generalization often leads to information loss at various levels, from schema structure to storage documentation. This disharmony is exacerbated by the lack of an adequate theoretical framework to guide metadata practices, as noted by Alemu et al. [3], who criticize the dominance of top-down approaches and the minimal sensitivity to linguistic diversity and cultural contexts. On the other hand, Khoo and Hall [4] added that inconsistencies in the use of controlled vocabulary and variations in metadata quality also hinder interoperability efforts, especially in systems with limited cataloging resources. Similar criticisms also arise from more recent studies. Shi and Donathan [5] warn that the application of global metadata schemes without local adaptation risks producing distortions in cultural representation, which impacts the loss of context and the decreased relevance of information retrieval results.

In a different context, Carrasco, Candela, and Marco-Such [6] demonstrate that the dominance of a single schema in the digital environment leads to a decrease in semantic diversity, as evidenced by quantitative measurements using an index. These findings reinforce that metadata interoperability is not just a technical issue, but also an epistemological problem that requires a framework capable of bridging the complexity of meaning and context. Some theoretical approaches attempt to address this issue through the frameworks of postmodernism and constructivism. The postmodern paradigm rejects the claim of universality of meaning in metadata and emphasizes the importance of pluralism of interpretation, contextuality, and diversity of its use. For example, Montenegro [7] revealed that the assumption of neutrality in Dublin Core can undermine local cultural authority, thereby potentially perpetuating certain power relations in metadata. Additionally, modern archival studies also highlight that metadata not only describes but also reflects institutional biases, dominant languages, and internal organizational policies. However, the postmodern approach is often seen as too focused on critique (deconstruction), making it less helpful when metadata needs to be translated into large-scale interoperable systems said Light and Hyry [8].

Shreeves et al., [9] said over the past two decades, metadata interoperability in digital libraries has often been treated as a syntactic and structural issue that can be resolved through format simplification and the use of open protocols. This approach is based on the assumption that metadata structures can represent information in a neutral and universal manner. However, this approach has been criticized for neglecting that metadata is not a value-free entity, but rather the result of social and epistemic constructions shaped by cultural, institutional, and linguistic contexts, Hjorland [5]. Various forms of these challenges arise with the urgent need to build a paradigm that can synergistically integrate technical and social aspects. Therefore, this paper proposes the adoption of a sociotechnical paradigm as an alternative approach in the study of metadata interoperability.

Method

This study uses a literature review approach to analyze the application of the sociotechnical paradigm in metadata interoperability in digital libraries. Literature sources were obtained from international journals, conference proceedings, scientific books, and research reports discussing metadata standards (MARC, Dublin Core, MODS, RDF), interoperability protocols (OAI-PMH), and frameworks such as Linked Data. Literature selection focused on publications that integrate technical, semantic, social, and institutional dimensions. The analysis was conducted thematically to group findings based on relevant challenges, approaches, and solutions, using the digital library development framework by Xie and Matusiak as a conceptual reference. This approach was used to link theory and practice, and to evaluate the success of implementation through case studies such

as Indonesia One Search and Finna.fi, resulting in a comprehensive understanding of the role of the socio-technical paradigm in building adaptive and inclusive metadata interoperability.

Result and Discussion

A. Sociotechnical Paradigm Approach in Digital Libraries

Theoretically, based on the Association of Research Libraries (ARL) in Xie and Matusiak [10], the concept of a digital library has key elements including

1. Not a single entity: Digital libraries are not a centralized system, but rather a network of interconnected resources.

2. Technology for connectors: Digital libraries rely on technology to connect resources from various sources.

3. Transparent connections: The connections between various digital libraries and information services should be seamless and invisible to users.

4. Universal access goal: The main objective is to provide universal access to everyone to the digital library and its information.

5. Beyond document copies: The digital collection is not limited to digital versions of physical documents. This collection also includes digital artifacts that cannot exist in print format.

The sociotechnical paradigm views a system as an inseparable combination of social and technical components, where optimizing only one side will not result in an effective system overall. According to the key elements of digital libraries by ARL, this perspective is highly relevant. Although the definition explicitly highlights technical aspects such as the need for technology to connect resources, transparent links, and collections in digital format, the meaning also implicitly and explicitly touches on crucial social dimensions. The goal of universal access is the clearest manifestation of social ambition, where technology is not just a tool, but a means to achieve information equity for everyone.

The sociotechnical approach to digital libraries also offers a framework that combines elements of information technology with the accompanying social, institutional, and cultural dynamics. This approach aims for the metadata governance system to be understood as the result of the interaction between technical devices such as formats, protocols, and information architecture, linked with social practices involving organizational policies, the role of librarians, and end-users' perceptions of information. Interoperability, within the sociotechnical framework, does not only refer to the success of data exchange between systems but also encompasses the context of semantic data exchange, contextual relevance, and cross-institutional collaboration in designing and managing metadata schemes [11] . This perspective reinforces the sociotechnical paradigm in viewing systems, emphasizing that to produce metadata as a result of the dynamic interaction between technological components and social components, several aspects are required, including institutional policies, organizational cultural values, user information literacy, and the context of data production and usage.

Recent studies on this approach have been adopted to address challenges in linked data programs, federated searching, and the development of national-scale discovery services. For example, Radulovic et al. [12] show that the adoption of linked data technology in national libraries often faces obstacles not due to technical factors, but because of differing institutional interpretations of metadata elements, as well as inconsistencies in descriptive policies. The socio-technical approach encourages dialog-based and adaptive semantic mapping, rather than rigid single standardization. This is in line with the findings of Wang & Yang [13], which emphasize the importance of involving

librarians in the curation process of linked data entities to maintain the diversity and meaning of the stored metadata.

Another element is conveyed by Stevens [14] by emphasizing that sustainable metadata interoperability can only be achieved through an understanding of work practices, institutional structures, and digital literacy that shape the information ecosystem. In the field of digital libraries, it is hoped that a sociotechnical approach will strengthen the position of metadata not only as a means of information retrieval but also as a collective representation of knowledge that continues to be a resource. Thus, this paradigm not only offers technical solutions but also a reflective approach to designing information systems that are more just, relevant, and user-oriented.

B. Principles of the Socio-Technical Paradigm in Metadata Interoperability

1. Joint change between technology and organization

Metadata interoperability is not enough just by following technical standards such as specific formats or protocols. Organizations also need to adjust their workflows to collaborate within a metadata sharing system. Technology and organizations must evolve together for effective metadata integration.

2. Standardization of meaning between institutions

Each institution or community can have its own way of defining a piece of information. Therefore, interoperability requires a process to standardize the meaning or significance of the metadata. This process is known as semantic mapping, which is an effort to bridge the differences in terms or structures between metadata schemas.

3. Cooperation from various parties

To achieve successful metadata interoperability, various parties need to be involved, not just system developers, but also librarians, researchers, and users. The involvement of all parties is important so that the metadata system being built can be widely accepted, relevant to needs, and truly usable in various contexts.

C. The Urgency of Implementing the Socio-Technical Paradigm in Web Scale Discovery Service

If linked to the digital library development model proposed by Xie and Matusiak [15], the sociotechnical approach aligns with the view that a digital library is an integrated system consisting of various components, including digital collections, metadata, technological infrastructure, user services, as well as social and institutional dimensions. In this model, metadata plays a central role as a link between digital resources and the user experience in finding, accessing, and understanding information.

The conventional approach based on the positivistic paradigm tends to define metadata interoperability in a limited way, namely as the system's ability to exchange data in standard formats, such as Dublin Core or MARCXML, through protocols like OAI-PMH. However, according to Xie and Matusiak [16], metadata interoperability is the result of simultaneous interaction between technological elements and social elements. The failure of interoperability often does not stem from technical constraints, but rather from the lack of documentation of local schemas, differences in the interpretation of metadata structures between institutions, or low user involvement in the system design process.

This can be examined in depth in the implementation of metadata interoperability in web scale discovery service (WSDS), as demonstrated by Indonesia One Search (IOS). As a national-scale discovery system, IOS integrates metadata from thousands of institutions including libraries, museums, research institutions, and cultural communities into a single search interface. Each institution has a different metadata schema, influenced by organizational needs, technical resources, and social and cultural contexts. In such conditions, interoperability cannot be simplified as merely the process of standardizing technical formats. A dialogue between institutions and a mapping of meanings sensitive to the diversity of structures, terms, and goals of information representation are required. The sociotechnical approach supports this effort by positioning metadata as a result of social and technological interactions, and emphasizing the importance of involving multiple parties, including librarians, system developers, data managers, and users, in the design and evaluation process of interoperability.

A similar experience is also seen in the development of Finna.fi, a national discovery service in Finland. According to Hormia-Poutanen et al. [4], Finna successfully integrated data from hundreds of institutions with very diverse backgrounds, not only technically but also in terms of language, institutional policies, and forms of collections. This success was achieved through a collaborative approach involving librarians, curators, archaeologists, system developers, and end-users in the design and evaluation process. The metadata schema used is adjusted to be flexible enough to accommodate the diversity of meanings and data contextualization, including support for multilingualism and local elements. The Finna case shows that metadata interoperability in WSDS depends not only on technical compatibility but also on the institutions' ability to collaborate, agree on meanings, and adapt descriptive practices within an inclusive and sustainable digital ecosystem.

Conclusion

Metadata interoperability in the context of digital libraries cannot be optimally understood if it only focuses on technical aspects and formal standards. This study shows that the positivist paradigm, which emphasizes the compatibility of schemas and technical protocols, is inadequate in addressing semantic diversity, socio-cultural contexts, and complex user needs. On the other hand, the socio-technical paradigm provides a more comprehensive approach by considering the interactions between technology, institutions, and socio-cultural aspects in the development of metadata systems. Case studies such as Indonesia One Search and Finna.fi demonstrate that successful interoperability requires collaboration among various stakeholders, negotiation of meanings, and adaptation to local contexts.

As an alternative, the sociotechnical paradigm becomes an important part. As described by Xie and Matusiak [14], Hormia-Poutanen et al. [4], and various other studies (Shi & Donathan [10]; Carrasco et al., [15]; Stevens, [12]), it provides a more comprehensive and adaptive approach. This literature analysis shows that the sociotechnical paradigm views interoperability as the result of multidimensional collaboration between technology, institutional structures, organizational culture, and user needs. For example, in cases like Indonesia One Search and Finna.fi, it provides the perspective that effective interoperability is not only measured through technical compatibility but also through the system's ability to align meaning and context between institutions inclusively.

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