Semantic Metadata Interoperability in Digital Libraries: A Constructivist Grounded Theory Approach

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ABSTRACT
This paper highlights problems of semantic metadata interoperability in digital libraries. The prevalence of a plethora of standards and a lack of semantic interoperability can partly be attributed to the absence of theoretical foundations to underpin current metadata approaches and solutions. Contemporary metadata standards and interoperability approaches are mainly top-down and hierarchical, and, hence, fail to take into account the diversity of cultural, linguistic and local perspectives that abound. To overcome this, it is proposed that a social constructivist approach should be adopted by libraries and other cultural heritage institutions when archiving information objects that need to be enriched with metadata, thereby reflecting the diversity of views and perspectives that can be held by their users. Following on Charmaz [1], a constructivist grounded theory method is employed to investigate how library professionals and library users view metadata standards, collaborative metadata approaches and semantic web technologies in relation to semantic metadata interoperability. This method allows an active interplay between the researcher and the participants who can be either Library and Information Science researchers, librarians or library users. Following the completion first phase of data collection, preliminary reflections are presented, with emphasis on how Library and Information Science professionals view current metadata practices, especially as used in academic library contexts. However, as the study is ongoing one, it is too early to generate theoretical categories and conclusions.

Categories and Subject Descriptors
D.2.12 [Interoperability]; H.3.7 [Digital Libraries]: Standards

General Terms
Design, Standardization, Languages, Theory

Keywords
Metadata, digital libraries, semantic interoperability, constructivist grounded theory, social constructivism.

JCDL'11, June 13–17, 2011, Ottawa, ON, Canada.

1. INTRODUCTION
Metadata is an important component of any digital library and repository system [2-7]. While the term metadata is a recent concept, the notion of describing books and other information resources is contemporaneous with as the establishment of libraries [8, 9]. Metadata is defined as data about data [10]. However, Lavoie and Gartner [11] and Day [8] argue that this definition is less helpful, suggesting that metadata should be defined in relation to its functions. One such definition, provided by the United States National Information Standards Organization (NISO) [7] which characterizes metadata as "structured information that describes, explains, locates, or otherwise makes it easier to retrieve, use, or manage an information resource." Significant investments have been made to specify metadata schemas by a number of national, multinational and international initiatives [12-14]. These exist alongside local standards, many of the latter, although almost unknown by the wider community, having been adopted by individual institutions. Based on current trends, it is reasonable to expect that the situation will continue to become more complex as time goes on. Each of these 'standards' requires implementers to adopt and adhere to some kind of a naming scheme, an identification mechanism, a controlled vocabulary, an authority control, an encoding scheme, a format and technology. However, on closer examination, it is apparent that there is frequently some internal inconsistency in what these standards require their implementers. Common problems include: imprecise definition of terms, ambiguous characterisation of metadata elements, as well as incomplete or otherwise incorrect identification protocols, conventions and encoding schemes [15]. In practice, these deficiencies give rise to serious difficulties for librarians and archivists. The diversity of metadata standards, the existence of local schemas and the heterogeneity in metadata usage and implementation has significant implications for institutions to provide seamless and integrated access to information resources when they attempt to share and exchange metadata as well as content across heterogeneous digital libraries. With growing trends towards establishing institutional, regional and international cooperation, such as the formation of the European Commission and the African Union, the quest for information sharing and exchange makes interoperability an important concern.

Interoperability is a broad term which encompasses the ability of separately developed systems to work together without end users

exerting significant efforts. Today, interoperability has become a catch phrase in many regional bodies that need to collaborate. The interest for interoperability emanates from various sources including the desire to enable seamless information exchange, cost savings, shielding tax payers from unnecessary bureaucracy, and facilitating business transactions [16]. In the context of digital libraries, interoperability refers to the ability to cross-search and integrate information resources from "multiple autonomous and heterogeneous information systems" [16]. It also refers to the ability of bridging between information silos, re-using information and understanding the exchanged information [17, 18]. However, according to Rothenberg [18], one of the challenges for ensuring interoperability is the fact that when systems are being designed, it is difficult to precisely determine what other systems would require from the system being designed.

Interoperability can be considered at various levels. Ouksel and Sheth [19] categorise it as system interoperability (compatibility between hardware and operating systems), syntactic interoperability (similarity in encoding and representation), structural interoperability (unified data-models, data structures and schemas) and semantic interoperability (consistent terminology and meanings). Expanding the concept into a broader context, Miller [17] has classified the term into six categories, namely, technical, semantic, political/human (referring to decisions that make resources widely available), inter-community (concerned with sharing interdisciplinary information across boundaries), legal (pertaining issues related to freedom of information, data protection regulations, and intellectual property rights) and international (related to the abundance of languages). Similarly, the European Commission in its Interoperability Framework Action Plan [16], stresses the need for political will, as well as mutual agreement between regional governments and stakeholders in order to streamline business functions and institutional activities. Interoperability is also a major national concern in many countries. For example, e-Government Interoperability Framework (e-GIF) in the United Kingdom focuses on technical aspects of interoperability, such as interconnectivity, data integration, e-services and content management. This framework aims at setting and adopting to standards and specifications such as Extensible Markup Language (XML) and Dublin Core [20]. It stipulates that "the ultimate test for interoperability is the coherent exchange of information and services between systems" [20]. The existence of various types and levels of interoperability clearly demonstrate that it is a multifaceted concern [18] and that achieving success would depend on paying attention to and harmonising several inter-related overarching factors.

According to Miller [17], in order to be interoperable, "one should actively be engaged in the ongoing process of ensuring that the systems, procedures and culture of an organisation are managed in such a way as to maximise opportunities for exchange and re-use of information, whether internally or externally." This, according to Miller, involves more than the use of compatible hardware and software. Rothenberg, holding a similar view, points out that interoperability "implies far more than simply getting ICT systems to communicate with each other," as it also implies compatible interpretations, policies, and procedures if one is to make sense of the exchanged information [18]. Both authors strongly advocate that, in order for systems to be interoperable, organisations that design and maintain such systems should not only take into consideration the technical aspects of each system but also bear in mind semantic, organisational, cultural, and legal issues.

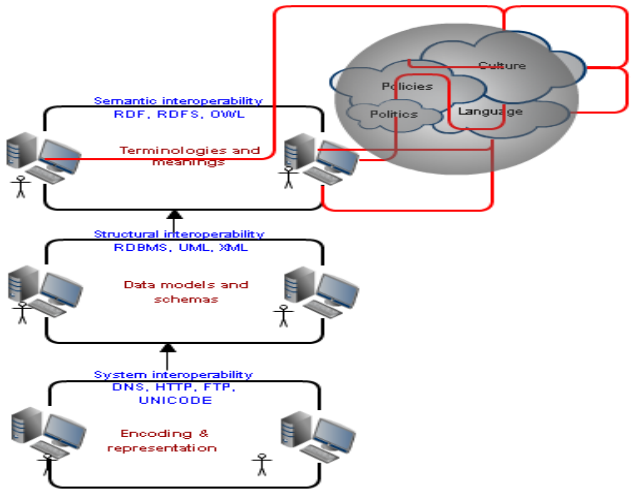

Fig.1. Metadata Interoperability Levels [15]

According to Haslhofer & Klas [15], metadata interoperability problems can be attributed to one or more structural and semantic heterogeneities. These include, among others, naming conflicts whereby two or more metadata standards use different labels for related concepts or purposes, such as 'Name', 'Author', 'Creator', and 'Composer' to refer to people and organisations who are responsible for the intellectual creation a work [17]. For instance, the elements 'targetAudience', in Metadata Object Description Schema (MODS), and 'TypicalAgeRange' in Institute of Electrical and Electronics Engineers' Learning Object Metadata (IEEE-LOM) both refer to intended target user. Another example would be '300$a' (Physical Description), in MAchine-Readable Cataloguing (MARC), and 'Format' in Dublin Core. Similar naming inconsistencies may occur the metadata model level too such as the use of 'Class' in Web Ontology Language (OWL), and 'Entity' in the PREservation Metadata: Implementation Strategies (PREMIS), metadata schemas. Heterogeneity problems can also be caused by identification conflicts, whereby two or more metadata standards adopt different types of identification mechanisms for their integral elements. Examples include the use of 'File Identifier' in Consortium of University Research Libraries (CURL) Exemplars in Digital ARchiveS (CEDARS), 'Reference Number', 'Object IID', and 'Persistent Identifier-PID' in the National Library of New Zealand (NLNZ) standard, and 'Assigned Identifier' in that of the National Library of Australia (NLA). Furthermore, Haslhofer & Klas also highlight conflicts that can arise from differences among various domains and the way metadata fields and vocabularies are employed in a particular domain. As Rothenberg [18] notes, the use of the term 'offshore' may have different connotations, depending on whether it is used in a maritime, foreign business or oil exploration context. Similarly, as used by the Flickr application, the term 'Apple' can refer to any edible fruit, the

Forbidden Fruit in the Bible, a computer brand, an abbreviated form of the place known as Apple Valley.

Terminological mismatches, due to the prevalence of synonymous and homonymous terms, are the most typical and common causes of semantic heterogeneity [15]. Other sources of mismatches that can result in interoperability difficulties include scaling/unit conflicts (mainly due to the non-adoption of the Metrics system by some countries and territories), constraints conflicts (different standards using dissimilar data encoding constraints), and representation conflicts (e.g., 09 May 2011 versus 09-05-11 or month-day-year (American) versus day-month-year (European) depiction of the same date) [15].

For digital libraries, achieving metadata interoperability, at present, is a big challenge [2]. The ideal solution to metadata interoperability difficulties would be the adoption, strict adherence to, consistent implementation of a single standard by all digital libraries [2]. Even though such an approach has been pursued by libraries in the past as exemplified by the adoption of the Dewey Decimal Classification system, the Anglo-American Cataloguing rules (AACR2), the MARC and, currently, Dublin Core, such efforts have had their own problems. Furthermore, the existence of several metadata standards, coupled with the proliferation of several "in-house" schemas has exacerbated the situation. Under such circumstances, achieving metadata interoperability, with the adoption of a single standard, becomes a daunting task [15]. In situations where several metadata standards co-exist, some of the approaches that have been employed to effect metadata interoperability include the use of metadata derivation, application profiles, metadata-cross walks (metadata matching), metadata registries and the use of semantic web technologies [2, 3, 7, 21]. However, it has been adequately demonstrated that even the wholesome adoption of all these approaches and methods cannot provide the required semantic interoperability for effective cross-searching, content sharing, and information integration. Hence, metadata interoperability still remains a big challenge.

Among the above mentioned approaches, metadata derivation involves developing a new schema from an existing one [2]. Examples include MARC-XML, MARC-Lite, and MODS, all of which have been derived from the MARC standard. As MARC is widely viewed as very cumbersome and complex, simpler schemas, considered easier and lighter for implementation, had to be developed [2, 22]. For example, Day argues that "MARC formats may not be the best 'fit' for the dynamic and fugitive resources that inhabit the web environment" [23]. Guenther & McCallum [22] note that the shift from the complex MARC format to a flexible and versatile XML encoding is a timely and important adaptation. Nevertheless, the principal problem with this approach is the fact that, as the problem of metadata interoperability is closely associated with each metadata element, depending on the way it is defined, labelled, represented, related to other elements, content values (controlled vocabularies), and constraints – whereby making the schema light does not necessarily ensure semantic interoperability as there will always be a need to make sure that fields in the light schema and their corresponding values (in the parent one) are properly understood by the end user or the system.

A second approach that has been employed to surmount interoperability difficulties is the use of application profiles [2, 24-26]. This is also known as a 'mix-and-match' solution, as it aims to bring together several elements from different schemas [5, 25, 27]. The idea of developing and using application profiles seems to offer a promising remedy. However, the problem of metadata interoperability is rooted in the way that each metadata element and its associated values are semantically defined and used. Nevertheless, current standards fail to address these fundamental, underlying issues. Furthermore, as pointed out by Haslhofer and Klas [15], metadata has different levels of abstraction: meta-model, metadata schema and metadata instance – which has a bearing on interoperability. It is incontestable that application profiles enable the sharing of best metadata practises and permit re-use of metadata elements and help in avoiding unnecessary duplication of effort. However, they are a schema level solution. So while exposing metadata schemas constitutes part of the solution towards interoperability, it does not specify how metadata records (content values) are exchanged and used. As Nilsson [6] argues, "the problem with defining meta-data application profiles using XML schema is that each application profile defines precisely which schemas you are allowed to use. Therefore, for each new meta-data vocabulary [that] you need to support, you will need to define a new application profile. This automatically puts a stop to the use of alternative meta-data descriptors, and results in an authoritarian limit on meta-data expressions." In this paper, it is argued that problems associated with rigid and authoritarian specifications need to be properly addressed in order for such solutions to scale.

The third solution to interoperability difficulties is metadata cross walking [2]. A metadata cross walk "is a set of transformations applied to the content of elements in a source metadata standard that result in the storage of appropriately modified content in the analogous elements of a target metadata standard" [28]. For instance, a metadata cross-walk can be performed between Dublin Core and MARC and the common elements can be used to merge records of information objects defined using these two different schemas. For instance, as the element "245 $a" in MARC is equivalent to the "Title" element in Dublin Core, a metadata crosswalk could be employed to retrieve and seamlessly integrate records containing a particular value in either of the two fields or both. However, such equivalency mapping is very cumbersome and resource intensive. Moreover, by mapping a richer metadata schema to a simple one such as MARC to Dublin Core, the fields that do not have a corresponding counterpart are lost. Nilsson has amply demonstrated that metadata cross-walks/mappings are only helpful as short-term solutions to difficult to making different standards interoperate seamlessly. Problems of cross-walking include, disparities in terminology that can result in an incomplete mapping issues related to the maintenance of the mapping schema, lack of scalability as the number of constituent standards increases, and the problematic nature of mapping the semantics [6].

A fourth approach to metadata interoperability issues is the use of metadata registries [2, 4, 24, 27, 29]. Metadata registries make various metadata specifications explicit, thereby enabling implementers to choose and pick elements from different sources when building applications that suit their purposes. The latter

may lead to the development of application profiles [30]. Although this is an important service, a problem still remains unresolved in that these registries do not hold metadata content values. It is important to note that these particular metadata interoperability solutions do offer some level of interoperability at the schema level. However, at present, they do not solve issues associated with as it stands now they do not deal interoperability difficulties at the semantic (content) level.

In contrast to the solutions suggested by Chan, Zeng, Nagamori and Sugimoto [2, 21, 31], Nilsson maintains that current metadata interoperability techniques and methodologies, such as metadata cross-walks, application profiles and metadata registries, only play either a marginal role or are severely limited. One of the problems he identifies is the limitations of XML to provide semantic mark-up to metadata schema and content. Standards such as MODS, MARC-XML and METS use XML as their data encoding structure. However, as Decker et al and Nilsson [6, 32] point out XML is ineffective for semantic interoperability. This is because XML "aims at document structure and imposes no common interpretation of the data contained in the document," [32] and, hence, does not embed semantics in its schema. On the other hand, Day, Nilsson, and Rothenberg [3, 4, 6, 18, 23] argue that semantic interoperability can be achieved through the use of semantic web technologies such as Resource Description Framework (RDF), RDFS (RDF-Schema), and OWL. It has been demonstrated that RDF's simple data model enables the creation of semantic links among information resources. An RDF schema adds vocabularies such - as Class, SubClass, Domain, and Range - to enable a more meaningful representation of resources. By extending RDFS with yet additional vocabularies, OWL allows the definition of additional semantic constructs such as equivalency, inverse and cardinality relations and constraints [33, 34]. One of the defining features of the RDF model is the ability to uniquely and globally identify resources and metadata attributes (relations) using Uniform Resource Identifiers (URIs). The use of URIs for metadata element names, labels, and relations, according to Nilsson [6], helps to avoid naming and identification conflicts in the use of elements. This is also suggested by Day and Rothenberg [3, 4, 18, 23]. Though there happen to be several academic papers and technical specifications regarding RDF, RSDFS, SPRQL, and OWL, there are no viable semantic web related metadata solutions up until now.

Semantic interoperability encompasses concepts that extend beyond the mere exchange of information, focusing on how the exchanged information can be meaningfully and semantically interpreted. This makes semantic interoperability an important issue for institutions. It involves, among other things, language, culture, values, and policies, and even politics. This also means that the issues underlying semantic interoperability should be addressed at different levels: primarily at the philosophical, theoretical, methodological as well as technological levels. This paper highlights the need to define the philosophical perspective in defining standards and metadata interoperability solutions. For instance, practices in implementing library standards such as MARC seem to imply an objectivist philosophical perspective, whereas in reality, libraries and the interpretation of their information objects (metadata) tends to be disparate, perhaps suggesting the need for an interpretive perspective. The design and deployment of Online Public Access Catalogues (OPAC) seem to favour an objectivist perspective, whilst the proliferation of Web 2.0 applications, such as social tagging (collaborative metadata), seems to follow a social constructivist philosophical perspective. Thus, the philosophical assumptions that underline the decisions of metadata standards setting agencies can significantly affect interoperability approaches and solutions.

To summarise, a review of the existing literature on metadata interoperability reveals that most authors start by addressing the 'how' instead of the 'why' of interoperability. While answering the 'how' question is crucial in achieving syntactic and structural interoperability, it says little about semantics. One of the major problems in this regard is the fact that semantic metadata interoperability solutions lack theoretical underpinnings. It is however important that such theories are built on a sound basis. These theories should be grounded in data and it is essential that such data is obtained from practising librarians and from metadata experts in the field of Library and Information Science field, as well as from library users.

2. PHILOSOPHICAL AND THEORETICAL FOUNDATIONS OF SEMANTIC METADATA INTEROPERABILITY SOLUTIONS

2.1 Philosophical Perspectives

The research will consider how a social constructivist approach can be adopted in order to achieve semantic metadata interoperability. As recommended by Guba and Lincoln [35], Grix [36], Creswell [37] and Charmaz [1], scholarly investigation should lay its foundation on the building blocks of research. According to Guba and Lincoln [35] the inquiry paradigms such as positivism, post-positivism, critical theory, and constructivism have three major questions to answer: what is to be known (ontology)? What is the relationship between the inquirer and the thing to be known (epistemology)? And how should the inquirer pursue his/her inquiry (methodology)? Each one of these philosophical assumptions should be addressed and their implications clearly understood by the investigator right at the outset of the research process. Furthermore, the assumptions should be guided by the nature of the research problem at hand, the investigator's experiences and the intended audience of the findings [37]. Such philosophical perspectives as to whether the investigator has adopted a positivist or interpretive paradigm should also be explicitly stated at the same stage.

In accordance with the above, it is felt that a thorough examination, and in-depth understanding, and a clear statement of the underlying ontological and epistemological perspectives will help re-evaluate the existing metadata standards and metadata interoperability solutions. For the purposes of this paper, an interpretive ontological perspective and a social constructivist epistemological approach are deemed appropriate. The paper's main contention is that current metadata practises are mainly top-down, hierarchical and stem from a foundationalism (objectivist) ontological viewpoint. Such a position as this, ontologically speaking, can only advocate a single solution to problems. It is worth noting that, though not explicitly stated in their policies, metadata agencies such as

MARC and Dublin Core can be considered as examples of such a top-down approach.

2.2 Adopting a Social Constructivist Perspective in Semantic Metadata Interoperability

According to Crotty [38] constructivism "posits that all meaningful reality is contingent upon human practises, being constructed in and out of interaction between human beings and their world, and developed and transmitted within an essentially social context." The underlying assumption is that meaning is constructed and shaped from objects with the active engagement of the observer/researcher. According to Duffy and Jonassen [39], social constructivism posits that "meaning is imposed on the world by us, rather than existing in the world independently of us. There are many ways to structure the world, and there are many meanings or perspectives for any event or concept." This is contrary to the objectivist view that "truth and meaning reside in their objects independently of any consciousness" [38].

One may question the relevance of social constructivism for semantic metadata interoperability. Semantic interoperability, by definition, deals with problems associated to information sharing and exchange. The goal of semantic metadata interoperability is to enabling information sharing and exchange through negotiated meanings of the terms and expressions [40]. The nature of knowledge in social constructivism focuses on "individual reconstructions coalescing around consensus" thus promoting shared and negotiated meaning [35]. Social constructivists assert that "realities are apprehendable in the form of multiple, intangible mental constructions, socially and experientially based, local and specific in nature, and dependent for their form and content on the individual persons or groups holding the constructions" [35]. Recent developments such as the shift towards web-based publishing media such as Wikipedia, the spread of social tagging, and the adoption of social networking applications, an overwhelming move towards the acceptance of disparate points of views and negotiated meanings, as well as a general, implicit, tendency to arrive at a neutral point of view, all point to a need for embracing a social constructivist perspective. Recognising and accepting the existence of multiple interpretations of an object obviously has a bearing on semantic metadata interoperability as it implies and accounts for differences in the interpretations of digital objects (information resources) among individuals, groups, countries and geographic regions.

However, an examination of present practises of libraries and archives tends to demonstrate a concentration of their efforts at finding a singular solution to their information organisation problems. The Anglo-American Cataloguing Rules (AACR), MARC and Dublin Core are notable examples of such attempts. The underlying assumption, in all of these three standards and similar ones, has been that cultural heritage institutions would eventually coalesce around a single metadata standard, hence clearing the way to achieving interoperability among various information systems. Major proponents of such a top-down solution include Melville Dewey [40]. Similar views regarding the organisation of digital information systems and the establishment of standards that govern their operations are still being propagated. Veltman, on the other hand, argues that the search for the single, ontologically true, metadata solution does not reflect the pragmatic reality that prevails at different institutions. As Veltman [40] correctly contends many of the international metadata initiatives focus "more on the universal meaning of the basic fields or elements (containers) than on the local and regional contents in those fields or elements." The question as to why all libraries do not just use a single standard might arise. The problem is related to the fact that libraries are cultural heritage institutions and culture is a fluid phenomenon. The latter's fluidity makes it difficult, if not impossible, to provide objective definitions and explanations to the objects housed in the former. Libraries and archives provide lodgings to cultural artefacts such as paintings, photographs, writings, as well as physical artefacts (eg. the Rosetta stone at the British Museum). By their very nature these objects convey different meanings for diverse user groups, and hence, can be interpreted variously. Put simply, human beings are highly unlikely to agree on a singular, top-down and hierarchical classification of objects. This assertion is likely to assume increasing importance when it comes to how museum objects, such as paintings, are depicted and interpreted. Thus, knowledge representation systems such as metadata standards should be able to reflect the various interpretations of reality. Unfortunately, most current standards tend to adhere to what is known as the ontologically and objectively true viewpoint which substantially fails to capture and represent local and/or regional perspectives and interpretations.

An attempt to overcome these shortcomings should be cognisant of the existence of a multitude of metadata standards, the prolificacy of metadata interoperability solutions, and the ubiquitous nature of digital libraries and repositories. Though these facts make the task appear daunting, one can safely assert that the problem of semantic interoperability is best addressed through collaborative approaches in which the web is considered as enabler and facilitator of such collaboration. An inherent advantage of the web is the virtual social space that it creates for fostering bottom-up collaboration. The web, especially, what Gruber [41] calls the 'social web' creates an "ecosystem of participation, where value is created by the aggregation of many individual user contributions." Gruber argues that such a web of collected intelligence can be combined with the potential of the semantic web, an approach that attaches meaning to data and integrates structured data from several sources, thereby creating new value from the data itself [41]. While reviewing recent developments, Shirky [42] and Weinberger [43] assert that collaborative tagging (folksonomy) is an enabler for implementing an effective information organisation system. On the other hand, standardisation agencies such as the Library of Congress, Online Computer Library Centre (OCLC), and Dublin Core Metadata Initiative (DCMI) tend to favour a common metadata framework that facilitates interoperability. In the middle ground are to be found the likes of Gruber [41] who point out that both ontologies and folksonomies can be mashed up in the attempt to establish a more efficient system of information organisation.

To conclude, what is evident in the design and structure of present day metadata approaches is the lack of a theory that substantiates any one of the solutions. Since metadata constitutes a central part of digital libraries, it is of paramount importance

that the choice of metadata approaches is underpinned by a theoretical framework. Considering the disparity in the nature of digital libraries, their collections and the varying user needs, a social constructivist philosophical approach should be adopted to address the issues of semantic metadata interoperability.

3. GROUNDED THEORY METHOD IN METADATA

3.1 The Grounded Theory Method

The grounded theory method was developed by Barney Glaser and Anselm Strauss in 1967 (for more on its origins: [1, 44-47]). It is a well suited method for qualitative research. The basic tenet of the grounded theory method is the concept of developing a theory that is grounded in data through simultaneous data collection and analysis techniques [1, 48]. Other characteristics of the method include avoidance of preconceived theories, pre-formulated hypothesis and the reflective and critical analysis of situations and context of a research problem or phenomena [1, 47].

Currently, there are three main approaches in the implementation of grounded theory method. The first approach is called the Glaserian approach (after the originator Barney Glaser), compels the researcher to postpone the process of literature review until such time as data analysis is completed and the theory is generated. The second approach came into existence when Anslem Strauss, who was also the co-author of the method, holds views different from that of Glaser. Glaser strongly opposed to Strauss and Corbin's detail procedures of data analysis [49, 50]. While Glaser wants to adhere to the original tenets of "The Discovery of Grounded Theory" [51], Strauss along with his colleague Juliet Corbin argues the method should be evolving in accordance with pragmatic situations [47]. These differences led to a split in grounded theory methodology. The second approach also called the Straussian grounded theory method. Yet, another approach, the third flavour, is attributed to Kathy Charmaz [1] who argues that both Glaser and Strauss tend to be positivists in their treatment of the researcher as a distant and objective observer in data collection and analysis. Charmaz's approach is called the constructivist grounded theory method which follows a constructivist philosophical approach wherein both the researcher and participants mutually co-construct meaning during data collection and analysis.

Classic grounded theorists, such as Glaser, espouse the view that the researcher should keep some distance in the research process so as not to inject bias and preconceived ideas into it. As opposed to this objectivist approach, later grounded theorists especially Charmaz [1] and Mills, Bonner and Francis [46] adopt a constructivist approach to grounded theory, emphasise the view that the interaction between the investigator and the participant such in interviews cannot be neutral as such. Mills, Bonner and Francis [46] argue that through active engagements during the interview process, ideas are raised, discussed and knowledge is mutually constructed. According to this view, the researcher and the participant co-construct data, in the process known as data generation. Like Charmaz [1], Mills, Bonner and Francis [46] advocate for non-hierarchical intimacy, reciprocity, open interchange of ideas and negotiation (includes agreeing on the location and time of interview). The researcher also has the opportunity to reflect on his/her viewpoints and perspectives [46], in a way similar to what happens during other conversations and academic discussions. By acting thus, the interviewer has the opportunity to voice his view points and perspectives as well as allowing the voices of the interviewees to be heard.

3.2 Constructivist Grounded Theory Method for Semantic Metadata Interoperability

As Lehmann [52] explains grounded theory is an appropriate method for information systems, as the domain deals with overarching components such as technology, data, procedures, and people. The patterns of behaviour, views and perspectives of users is considered as the core component hence grounded theory fits with the study of these patterns. Allan [53] also contends that grounded theory is a systematic and rigorous method in information systems research. He outlines how the procedures such as open coding, constant comparison, memo writing, and theoretical coding can be used to conceptualise actual problems in information science research and help to generate theory to explain patterns in behaviour, users' satisfaction and other relevant research issues. The method is especially relevant in areas where there is a scarcity of theories. The sub-category of information systems that deals with digital libraries is such a domain, as it is one where the generation and use of theories is scant [52, 54-56]. Andersen and Skouvig [54] argue that "for knowledge organization to uphold significance recognizable by society, it needs to engage in and be informed by theories and understandings that locate and analyze society and its historically developed forms of organization." There is therefore a need to develop theories.

As semantic interoperability is of a qualitative concern [15], grounded theory, as a qualitative data analysis method, is a fitting methodology to explore and understand the issues as it studies actualities instead of potential applications of a solution or standard. The conceptualisation inductively generates concepts, categories and theory from users' actual experiences in using library systems and resources. A grounded theory will then emerge from the conceptualisation.

3.3 The Research Question

There are contending views in grounded theory, as to whether the research question needs to be formulated before data collection begins. On the one hand, Glaser [45] argues that solely identifying a general research interest is adequate and the researcher should not formulate any specific research question at all. However, on the other hand, Strauss and Corbin [47] and Charmaz [1] contend that it is impractical to expect the researcher to delve into the research 'field' without some sort of pre-conceived research questions. This research takes the latter approach because it is argued that the research question should be first understood and stated so as to ring-fence the scope and delimit the issues that need to be addressed. According to Strauss & Corbin [47]"it is impossible for any investigator to cover all aspects of a problem. The research question helps to narrow the problem down to a workable size." In addition, it is also argued that that the research problem should guide the choice of methodology [36, 37, 47]. In light of this argument, the following broad research questions are formulated for this research:

- What are the experiences of librarians and users in using metadata while accessing information from websites, digital libraries and information repositories?
- What kinds of solutions, in relation to semantic metadata interoperability, do librarians and users consider practical for facilitating information exchange, information sharing, and data integration?
- How much useful do librarians and users consider the semantic web and web 2.0 technologies in relation to semantic metadata interoperability?
- How do librarians and users compare the value of the top-down, hierarchical approach and the bottom-up user driven approach to metadata development, in relation to semantic metadata interoperability?

Adopting a constructivist epistemological approach and grounded theory method, the specific objectives of this thesis are to:

- Gather views and opinions, through interactive and iterative in-depth interviews, of researchers, librarians and users on how they use disparate digital libraries and repositories;
- Analyse, through identification of concepts and categories from the data collected, the users versus experts view of metadata in terms of users' experiences and examine how the views affect metadata interoperability solutions;
- Interpret librarians and users views and experiences of Web 2.0 and Semantic Web technologies and its implication in semantic metadata interoperability;
- Examine, through discussion with respondents, how a top-down versus bottom-up approach to metadata affects semantic interoperability; and finally
- Develop a theory that overarches the concepts and categories derived from the data collected and analysed, which is capable of explaining and predicting semantic metadata interoperability issues and help guide action in digital libraries and repositories.

The findings of this study are expected to contribute to a better understanding of the metadata approaches such as how high-level ontological/philosophical approaches adopted by metadata agencies affect semantic interoperability. It can also help to better understand whether top-down, bottom-up or mixed approaches are viable to ensuring better semantic metadata interoperability. As indicated by Shirky [42], the question whether the world makes sense or humans make sense of the world impacts how metadata is created and utilised. The philosophical perspective also leads to question whether the role of metadata standards and metadata is to accurately represent reality or make information resources findable to the user. If metadata agencies and experts aim to make information findable, then it means anything that serves this purpose such as social tagging (web 2.0) would be relevant. The study will also explore how the unstructured and uncontrolled metadata generated from Web 2.0 applications would be better harnessed in digital libraries along with the hierarchical and authority-controlled metadata created by librarians.

In current practises, it is librarians who describe objects with metadata. To begin with, the schemas are mainly lack elements to capture semantics (about-ness of the object). The fields such as author, title, year, and publisher are mainly objective. What are lacking are elements that represent the subject of an information object such as: What is it about? How is it related to other objects? How particular information object agrees/disagrees/supports to one or more information objects? Most libraries provide very little information regarding the semantics and subjective aspect of information objects. This is because, first of all, standards agencies are mainly concerned about the physical characteristics of an object. Secondly, librarians are not always experts to adequately describe the semantics aspect of information objects. Third, librarians increasingly find it difficult to describe digital objects as the size of the collection grows exponentially. In other words, it is expensive for libraries to semantically describe the ever increasing size of digital objects such as photograph collections. Fourth, as one research participant indicated "the way Asians describe Asian art is quite different from the way a Westerner does" thus requiring collaborative metadata approaches.

Based on data analysis, this research intends to provide a theoretical framework which in turn indicates whether there is a need to:

- Redesigning metadata schemas in a manner that is pertinent to capture semantics about digital objects;
- Giving up control by librarians so that not only librarian-created metadata is acceptable and usable but also user generated metadata is collected and harnessed;
- Cataloguing collaboratively with other librarians from other countries, cultures and institutions.

3.4 Data Collection in Constructivist Grounded Theory

3.4.1 Participants

In the current study, three categories of participants are involved: academicians in the field of library and information science (including lecturers and post graduate students), librarians, and general library end-users. The selection of these participants is essentially purposive. One of the features of a grounded theory methodology is the fact that the number of participants (sample size) cannot be predetermined beforehand. Instead, the concepts and categories that emerge from the analysis of the first phase of data collection will be used to plan and implement the next phase of data collection until such time as theoretical saturation is reached. This happens when additional data fails to provide insights regarding the emergent concepts and categories [57].

3.4.2 Choice of Research Site

The initial site selected for the study is the School of Information Studies, Tallinn University, Estonia. Beginning in 2008, the university has hosted a number of MSc students in Digital Library Learning (DILL), under the EU-funded Erasmus Mundus

programme. In the initial Phase-I data collection exercise, a total of 11 participants have been interviewed, from February 21st through 25th, 2011. The interviewees consisted of 2 lecturers, 1 PhD researcher and 8 MSc students. The countries of origins of these participants include Bangladesh, China, Denmark, Estonia, Ethiopia, Italy, Turkey, Uganda, Venezuela and Zimbabwe.

3.4.3 In-Depth Interviews

In a constructivist grounded theory methodology, both the interviewer and interviewee are actively engaged in conversations. Intensive interviews are conducted mostly with open-ended questions. According to Charmaz [1] "the in-depth nature of an intensive interview fosters eliciting each participant's interpretation of his or her experience." As recommended by Charmaz, intensive interviews should be contextual and negotiated. As part of the Phase-I data collection endeavour, introductory contacts were made via email in order to ascertain the willingness of each participant as well as reach an agreement as to the timing and venue of the interview. Before the start of each interview, a Research Background Information Sheet and a Consent-to-be-Interviewed Form were distributed. Interviews were voice recorded. Interviews were made purposefully informal so as to encourage dynamic participation in the discussions on the part of interviewees. Furthermore, rather than following a scripted question and answer approach, a more engaging approach was followed, using open-ended questions.

As pointed out by Charmaz [1], interviews in constructivist grounded theory enable the researcher to ask for more detail, to delve into an issue, to go back and forth among important points and request more explanation. Finally, while utilising this approach, it is also important to summarise the participant's views and reflections so that the interviewer confirms that they have been properly understood. Putting it in another way, it is essential that the participant receives "affirmation and understanding" [1].

4. PRELIMINARY REFLECTIONS

This research is still on-going. However, in grounded theory it is permissible to reflect on issues that are discernible from participants' responses. For sure, the full details of concepts and categories are expected to emerge as an output of the data analysis process. In what follows, an attempt will be made to convey some of the tentative reflections, based on the data that has been collected so far.

4.1 Prolificacy of Standards

All participants acknowledge the existence of very many standards. Some even repeated the often cited adage that "the good thing about standards is that there are so many you can choose from", making the selection process a daunting task. One participant expressed the opinion that "libraries should base their [selection] decisions on the type of resources and the subjects they are describing." It is also pointed out that interoperability is a much sought after issue, even if it is a complicated one. Participants have alluded to the complexity of MARC as well as the simplicity of Dublin Core, while noting that simplicity comes at the cost of metadata richness.

4.2 The Open Public Access Catalogue (OPAC)

Most participants are unanimous in that they find OPAC old-fashioned, especially in comparison to popular search engines such as Google. For example, most OPACs do not seem to have alternative spelling options. The lack of such seemingly simple features makes OPAC less useful. In addition, most OPACs do not allow users to rate, comment, review and share resources with other users. As found out from the interviews, the participants rarely go to the library in person. This is mainly because they could access the information resources from electronic information services including library databases and e-journals. One participant even mentioned the fact that he has never gone to the library during the past two years. Some respondents view the library as a place that is not important to them. Most asserted that they rarely use the library's OPAC. One participant sees the OPAC as a tool that was born to replace the card catalogue. He ironically stated that OPAC is the "biggest innovation for libraries that ever happened" believing that libraries are changing too slowly to trying to cope with users' novel needs and expectations. Another participant said that the OPAC is made for books and fits the physical attributes of the books and less to other genres of information. He cited MARC as an example of such an attempt to reutilising the descriptive standard that had been designed for books to other genres of resources such as e-journals, CDROM, music, and posters. Hence, he argues that we have now a different information landscape but a standard that is anachronistic. According to participants, most OPACs lack interactively and are mainly static.

4.3 Top-Down Hierarchies versus Bottom-Up Approaches

When it comes to classification systems (standards) and collaborative (non-standardised) approaches, the views of the participants were very diverse. However, there is a consensus among the responses that the existing classification systems and the new bottom-up approaches of tagging can be utilised together and should not be considered as opposing methods. Some are however, wary of the lack of control and structure in web 2.0 applications such as tagging. One participant reflected on how some web 2.0 technologies come and go. She stressed the need to answer why we use a specific technology before starting to use it in library functions. She cited the example of Second Life and how libraries jumped into the bandwagon of just being part of Second Life, while librarians creating their avatars without answering the why of such technologies. She said that, currently, the use of Second Life in libraries has diminished. She added that she does not see web 2.0 technologies replacing the old systems of information organisation. Another participant stressed the need for libraries to provide richer description of library collections. In order to be able do this, he recommended that librarians should collaborate worldwide. According to him, librarians should be permitted, by their institutions, to catalogue collections of other institutions and vice versa, instead of relying on metadata records from proprietary companies. He pointed out that "the way Asians describe Asian art is quite different from the way a Westerner does."

Another participant stated that the issue of using standardised approaches (such as hierarchies and categories) versus web 2.0 technologies is more of a philosophical nature than technological. In support of this, he cites the "Divine Comedy", where the organisation of the poem reflects the theoretical (philosophical) framework of Italian society at that time. According to him, the work is a complete summary of all the medieval beliefs and church teachings. Furthermore, the division of the poems is well thought out, each category having 33 divisions, which along with the introduction brings the total number of categories to 100. He then compared this with the Dewey Decimal Classification system. He indicated that both Dewey and Dante represented cultural frameworks of their societies and that they were right in their own ways. He noted that the situation now is different "because there are too many traditions altogether and we don't believe any more in a rigid, [monolithic], structure. We [do] believe in change." This change, the participant believed, has brought yet another challenge: which of the systems (standards, frameworks, systems) should libraries use in such an ever changing tradition? He also said that the existence of structures and rules in bottom-up approaches should be acknowledged. He advocated thus: "I believe that when we talk about Wikipedia, the crowd sourcing, the power of the crowd, and the bottom-up approach, we always think about democracy. It is a very beautiful world but there is always the risk of it being an empty world. Because there is an assumption that, in a democracy everyone can do what he/she wants." He continued stating that, in such a freedom there is always an obligation to act within the strictures of the community and within its accepted bounds. The limits can be as strong as a hierarchy, in which one cannot go beyond it, or they can consist of more flexible limits. It is not complete anarchy. Hence there are always laws, bounds, and limits- there is always a structure. The important question is how much does this structure allow one to accommodate the large amount of useful information?

5. CONCLUSIONS

There is no lack of metadata standards. However, the main challenge in today's digital libraries is for institutions to provide seamless access to information resources and for the users to make sense of the information they have accessed. The existence of several standards poses a technical and semantic challenge of interoperation between various digital libraries and repositories. The approaches to metadata interoperability currently focus on providing technical solutions. However, not all these methods provide the required semantic interoperability for effective cross-searching, content sharing, and information integration. Hence, semantic metadata interoperability remains to be a big challenge.

It is argued that there is a lack of theoretical framework to underpin metadata approaches and semantic interoperability solutions. The current interoperability solutions such as metadata-mapping, metadata registries and application profiles focus solely at a syntactic level, hence failing to address the semantics aspect of the problem. It is also argued that present metadata approaches are mainly top-down and the actual users are not involved. Therefore, rather than trying to force interoperability solutions around a single standard, fostering an approach that promotes and encourages diversity seems prudent, as the latter approach is more attuned to human nature and the operations of its institutions. The focus should therefore be on bridging the semantics of the elements and metadata values that are being employed in various standards and digital libraries. Cultural artefacts very often lend themselves to various interpretations and contexts. As a result, most are described in varying metadata schemas, which in turn are developed at local, national, regional and international levels. Respecting and accommodating such differences, while pursing semantic consistency through a diversified approach would accrue meaningful results in the endeavour to achieve semantic interoperability. The paper focuses on solutions that respect diversity for a simple reason that a single solution or meaning cannot be enforced amidst cultural differences. It is argued that semantic interoperability does not, in any way, imply a singular understanding of a phenomenon. Instead it is mainly about allowing divergent groups to understand the intentions of each other when assigning meaning to a specific information object. Due to the very nature of the diversity inherent in institutional and cultural interpretations as well as differences in the usage of terms in metadata vocabularies, semantic metadata interoperability issues can better be addressed by adopting a social constructivist philosophical approach and by utilising a constructivist grounded theory methodology.

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