Knowledge Organization in the Intersection with Information Technologies†

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Abstract: This paper analyzes the historical role and possibilities of knowledge organization (KO) in relation to information technologies (IT). Different moments in history that are analyzed include the development of the Internet, the World Wide Web, the Semantic Web, problems of artificial intelligence, Web 2.0, and linked (open) data. The paper concludes with the analysis of some IT applications, challenges and opportunities in which KO theory and fundamentals might play a key role in the new environment, as well as the transformation of the field.

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1.0 Introduction

Information scientists and professionals sometimes perceive a disconnection between the theory and fundamentals of knowledge organization and the most technological cutting-edge applications in the field, such as in information retrieval. This division between these two camps (or, as Tennis (2015) has put it, philosophy and practice) also presupposes the non-necessity and irrelevance of theory in LIS education, inasmuch it has been made invisible in the technologically-driven practical front. The lack of substantive intellectual content has also caused human-based activities to be increasingly challenged by computer-based retrieval techniques (Hjørland 2003; 2008), while indeed human expertise and knowledge organization theory might play a very important role in aspects such as searching, using and designing databases (see for instance Hjørland 2015). New technologies such as intelligent agents, applications associated with the Semantic Web, linguistic and statistical techniques associated with inference rules and machine learning, many of them related to the field of artificial intelligence and non-human ways of processing, seem to have ignored and relegated theories and human practices in knowledge organization into the background. The aim of this study is to contribute to the restoration of the historical role and relevance of knowledge organization at its most social, theoretical and ethical side, in the development of the technological front.

In this paper, I analyze the historical role and connections between human (social) intervention in knowledge organization and the emergence of information technologies that underlie information systems in the digital environment. This methodology might correspond to a discourse analysis (e.g., Frohmann 1994; 2001; Budd & Raber 1996; Budd 2006; Martínez-Ávila 2012a; Campbell 2015) of the genealogies and historical emergencies of the concepts related to the intersection of knowledge organization and information technologies, in order to reveal the discursive formations, continuities and strategies of control that affect the construction and perception of the field. Some of the historical moments that are analyzed regarding the possible discontinuity in the dichotomies human intervention/machine processing and knowledge organization/information technologies (assuming that human-intervention and knowledge organization are the Foucauldian "others" in the binaries) include the birth of the Internet and the World Wide Web, the historical developments in artificial intelligence (AI), the birth and discourses of Web 2.0, and linked (open) data. The selection of these moments for the analysis followed criteria of scientific consensus in the literature and the historical relevance for the field, such as the role of Tim Berners-Lee in the development of the World Wide Web, the Dartmouth Conference for the development of the artificial intelligence field, etc.

2.0 A brief history of the Web

The origins of the Internet date back to the 1960s with the developments in packet switching, that is, a technology to communicate blocks of data, and the ARPANET (Advanced Research Projects Agency Network), the world's first packet-switching network developed by the U.S. Department of Defense. Although it is commonly believed that the aim of the ARPANET was to create a network resistant to nuclear war, some of the people involved in the development of the Internet have claimed (Leiner et al. 2000) that this is a "false rumor." Indeed, as Himanen (2001, 212) has pointed out, the project's director, Lawrence Roberts, "envisaged a net as a means of advancing the cooperation of the computer scientists." Actually, the Network Working Group, a selected group of hackers and university students leading the development of the network, operated under the free software principles of sharing and making information available: anyone was allowed to contribute ideas, which were then developed collectively (183). It is also worth noting that although when we think about the Internet we think about the TCP/IP model, that includes protocols such as the Transmission Control Protocol and the Internet Protocol, this was not the only possibility. The two main standardization organizations at the time, the CCITT and the OSI, had their own official standards: the X.25 and the ISO. According to Abbate (1999), one of the main reasons why the protocols of these standardization organizations did not succeed was the more closed nature of these bodies of operation.

Also during the 1960s, although independently from the development of the Internet, the Library of Congress developed and implemented MARC, the Machine Readable Cataloging format, under the same principles of collaboration and sharing of electronic information that was sought with the development of the Internet, cooperation of the catalogers in this case. The philosophy behind MARC was that instead of having multiple catalogers repeatedly describing the same resources on their own, the effort of one cataloger could be shared with many catalogers if they used a common format. By the 1970s, the MARC format had become the international standard for dissemination of library cataloging data, and bibliographic networks were organized to support cooperative cataloging and sharing of records, in the form of computer-assisted cards. More recently, with newer technologies, MARC has been criticized for being too much based on the traditional catalog card and not taking advantage of all the possibilities that technologies offer (see for instance Tennant 2002; Coyle and Hillman 2007). However, MARC was mainly concerned with the way to encode the descriptions to electronic form, and the key point is that the Internet and its descendants became some of the main mediums for the storage, sharing and retrieval of this data.

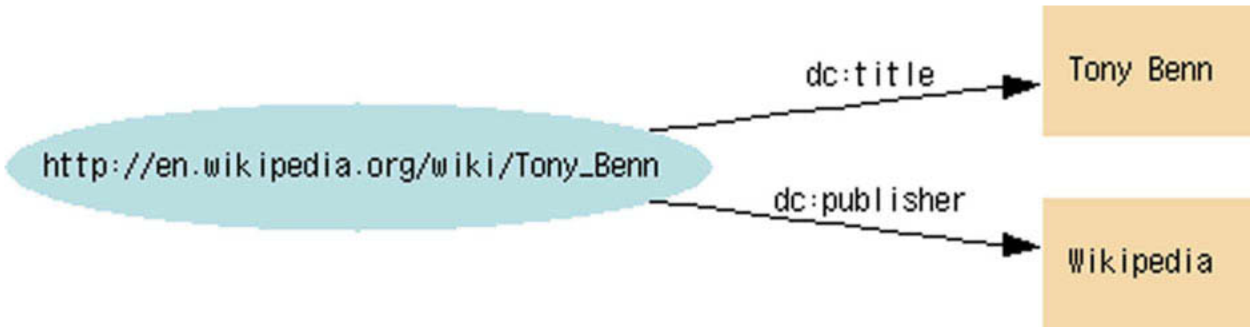
During the following decades, the technologies and ideas of the Internet kept on changing. By the early 1990s there were several serious candidates for a global net; the World Wide Web envisaged by Tim Berners-Lee was just one of them. One of the strongest competitors of the World Wide Web at that time was the Gopher Information System, developed by the University of Minnesota. However, as Berners-Lee pointed out, the end of Gopher happened when the school announced that it was reserving the right to charge people for the use of the Gopher protocols. Although they never did it (Berners-Lee 1999, 73), this was seen as an act of treason in the academic community and the Internet community. Berners-Lee, on the contrary, made sure the CERN, the institution he was working for at the time, would allow him to keep the development of the Web entirely open. And as some authors have pointed out (Himanen 2001, 214), this openness in addition to the social model (as was the case with the Internet) was one of the main advantages and factors in the success of the World Wide Web.

At the same time, during the early 1990s, OCLC started the Internet cataloging project, in which librarians from all types of libraries volunteered to contribute MARC records they created for Gopher servers, listservs, FTP and websites. It is important to note that, although these bibliographic networks had been sharing records since the 1970s, institutions such as OCLC and the Library of Congress have always kept the pace of technologies and have been aware of the latest IT possibilities to apply to KO, also probably contributing to the development of these technologies.

During the mid 1990s, once the World Wide Web was established and started to be used massively, Berners-Lee began to work on what he thought should be the future of the Web: the Semantic Web. In his 1998's "Semantic Web Road map" he wrote (1998a): "This document is a plan for achieving a set of connected applications for data on the Web in such a way as to form a consistent logical web of data (semantic web) .... The Semantic Web is a web of data, in some ways like a global database." In 2001 (Berners-Lee et al., 1), he also extended this definition stating that "the Semantic Web is not a separate Web but an extension of the current one, in which information is given well-defined meaning, better enabling computers and people to work in cooperation." According to Berners-Lee, the main characteristics of the Semantic Web are:

– Expressing meaning, that is, bringing structure to the meaningful content of Web pages, creating an environment where software agents roaming from page to page can readily carry out sophisticated tasks for users without discriminating among types of information, language, cultures, etc.
– Knowledge representation: for the semantic web to function computers must have access to structured collections of information and sets of inference rules that they can use to conduct automated reasoning. To achieve this, two main technologies were proposed for the development of the Semantic Web: the eXtensible Markup Language (XML), to allow people to create their own tags and add an arbitrary structure to the documents, and the Resource Description Framework (RDF), to express meaning and encode it in sets of triples (subject, predicate and object), that can be written using XML tags.
– Ontologies, or documents or files that formally define the relations among terms, typically having a taxonomy and a set of inference rules. Here, ontologies can be used to deal with problems related to terminology and ambiguity.
– Agents, or programs that collect Web content from different sources, process the information and exchange the results with other programs. To increase their effectiveness, machine-readable Web content and automated services should include semantics.
– Evolution of knowledge: here it is said that in naming every concept simply by Uniform Resource Identifiers (URIs), anyone can express new concepts that they invent with minimal effort and link these concepts into a universal Web.

Figure 1 illustrates an example of knowledge representation using RDF and XML. Here, it is stated in a machine-understandable language that "Tony Benn" is the title of the resource, not perhaps the author or any other personal role as one might have guessed when seeing a personal name, and that "Wikipedia" is the publisher of the resource. In the XML file, it is stated, also in a machine understandable language, that the file will use RDF and the Dublin Core metadata schema to specify the meaning of the tags (adding semantics to the plain text). The exact definition and meaning of these schemata are specified in

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<rdf:RDF
xmlns:rdf="http://www.w3.org/1999/02/22-rdf-syntax-ns#"
xmlns:dc="http://purl.org/dc/elements/1.1/">
<rdf:Description rdf:about="http://en.wikipedia.org/wiki/Tony_Benn">
<dc:title>Tony Benn</dc:title>
<dc:publisher>Wikipedia</dc:publisher>
</rdf:Description>
</rdf:RDF>
```

Figure 1. Example of RDF graph and XML. Source: http://commons.wikimedia.org/wiki/File:Rdf-graph-example-TonyBenn.png.

the referred namespaces starting with xmlns. In this example, after providing the resource that is being described, "http://en.wikipedia.org/wiki/Toni_Benn" (the subject), it is stated that the title, according to the definition of title in Dublin Core 1.1 (a predicate), is "Tony Benn" (an object), and the publisher (another predicate) is "Wikipedia" (another object). This information can be exported and shared in a form that others can understand using the XML format. The advantage of this representation is that machines are able to process the meaning of this information and treat it in a way that helps improve its use and retrieval automatically.

As for the role of ontologies in the Semantic Web, they can be used to minimize the ambiguity of the terms through the relations that are established between the concepts, entities, terms and categories in a given domain. Ontologies can be used to specify the meaning of terms so machines can automatically process the information accordingly. The dependence of these meanings and their relations to a specific domain (thus making impossible a "universal ontology") and the human need to define these relationships in the specific domain, strengthen their link with human intervention and the possibilities of theory in knowledge organization for in the Semantic Web. It is important to emphasize here (as argued in Martínez-Ávila and Fox 2015) that the Semantic Web is dependent on ontologies, and an ontology is dependent on the epistemological point of view. Regarding the relation of ontologies to artificial intelligence, Noy and McGuinness (2000) have highlighted the multitude of definitions of "ontology" in the literature on artificial intelligence, some of them contradictory and many of them also showing a strong relationship with other classical concepts of knowledge organization, such as categorization and classification. A detailed analysis of the discourses (such as the philosophy and computer science fields) shaping the concept of ontologies, in relation to knowledge organization, has also been conducted in Martínez-Ávila and Fox (2015).

However, not all of these ideas behind knowledge representation in the Semantic Web discourse are new. In addition to resembling some of the traditional practices of KO and resource description, a similar concept of knowledge representation has been used in the artificial intelligence field with not very good results.

3.0 History and problems of artificial intelligence

The term "artificial intelligence" was first coined in 1955 by McCarthy (1955) in "A Proposal for the Dartmouth Summer Research Project on Artificial Intelligence." However, the birth of the artificial intelligence field is generally established in the summer of 1956 (Crevier 1993; Russell and Norvig 2003; McCorduck 2004), when the Dartmouth conference was actually held. A definition of artificial intelligence given by McCarthy (2007) is "the science and engineering of making intelligent machines, especially intelligent computer programs. It is related to the similar task of using computers to understand human intelligence, but AI does not have to confine itself."

Although the AI field had some years of growth, optimism and plenty of funding during the following decades (with success in some applications such as computer chess), it also had some setbacks due to the impossibility of achieving some of its ambitious goals. In addition to several small episodes that gradually undermined the trust of the field, research on artificial intelligence had two major crises: one in 1973-1980 due to cutbacks to academic AI research in the US and in the UK, and another one in 1987-1993 with the collapse of the Lisp machine market and the cancellation of new spending on AI by the Strategic Computing Initiative. These major setbacks in the history of AI received the name of "AI winters," and within the field, the threat of a new AI winter together with the classical problems put almost any new big AI project under suspicion. This is believed to be one of the reasons why, as pointed out before, some AI researchers have chosen to call their work by different names even when the same technologies are being used.

According to Russell and Norvig (2003), some of the main problems that led the AI field to these AI winters in the past are commonsense knowledge and reasoning. Many of these problems related to disambiguation and machine translation are still open today. Another major problem in artificial intelligence is "knowledge representation," concerned with representing knowledge in symbols to facilitate the inference (reasoning) from those knowledge elements and the creation of new elements of knowledge. From the AI point of view, the concept of knowledge representation is the same as in the Semantic Web. However, Berners-Lee urged the community to clarify from the beginning that a Semantic Web is not artificial intelligence, as well as to clarify the differences between his Web and past AI technologies such as The CYC Representation Language (CycL) and the Knowledge Interchange Format (KIF) (Berners-Lee 1998b):

> A Semantic Web is not Artificial Intelligence. The concept of machine-understandable documents does not imply some magical artificial intelligence which allows machines to comprehend human mumblings. It only indicates a machine's ability to solve a well-defined problem by performing well-defined operations on existing well-defined data. Instead of asking machines to understand people's language, it involves asking people to make the extra effort.

In short, many of the problems that affected knowledge representation in the AI past (such as centralization, scalability, merging separate knowledge bases, the need of using the same terms for common English words, etc.) would be worked out with the participation of people and with the global use and decentralized description of resources using the supported technologies and standards that enable interoperability. Many of these standards would be developed in a social way under the coordination of the W3C. Indeed, this social participation for knowledge representation seems to be just an extension of Berners-Lee's original view of the World Wide Web as a social tool (1999, 123): "The Web is more a social creation than a technical one. I designed it for a social effect-to help people work together—and not as a technical toy. The ultimate goal of the Web is to support and improve our weblike existence in the world."

On the other hand, the importance of the social and cultural aspects in the creation and representation of knowledge is something that is also starting to be recognized in the AI field. For instance, Clocksin (2003) has outlined some elements of a new conceptual framework for AI that were shaped by Weizenbaum's observation (1976) that intelligence manifests itself only relative to a matrix of social and cultural contexts. However, when talking about a social web, it is impossible not to think about another term that was popularized by O'Reilly between 2004-2005: the Web 2.0.

4.0 Web 2.0 and the power to tag

O'Reilly (2005), reviewed some of the new advances and developments of the Web following on the 2001 bursting of the dot-com bubble, including Google, BitTorrent, Wikipedia and more. According to O'Reilly (2005, 2), "the central principle behind the success of the giants born in the Web 1.0 era who have survived to lead the Web 2.0 era appears to be this, that they have embraced the power of the web to harness collective intelligence." Although many of the Web 2.0 applications used by O'Reilly as examples are now outdated, it is important to see that there is some degree of "KO" intervention by users on them. For instance, while in the old days people used to speculate with web domain names, such as registering URLs including names of companies before companies could do it so they had to buy them, ranking algorithms in search engines such as Google made it possible to retrieve websites with unrelated names in the URLs by counting the terms that are in the source code and the income links, theoretically considering the meta keywords used to describe the content of the website (algorithms that vary from time to time and, by the way, are dependent on the arbitrary decisions of their designers, as noted for instance in Segev 2009; Hjørland 2013, Martínez-Ávila et al. 2015).

Another application in Web 2.0 related to KO, probably one of the most important ones, is the use of social tagging to categorize resources by people and the development of "folksonomies," what O'Reilly (2005, 2) called "a style of collaborative categorization of sites using freely chosen keywords, often referred to as tags." Taylor and Joudrey (2009, 366) commented about this, saying:

> The implication is that if enough users tag enough resources, sufficient data can be aggregated to achieve stability, reliability and consensus. In order for this data to be useful in augmenting current approaches to subject access, though, a critical mass of tags must be accumulated. The idea is that many tags applied to discrete resources by myriad individuals (who are tagging for countless reasons) will provide sufficient information to understand the nature of the resource and to allow us to take technological advantage of an inexpensive way to organize Web-accessible information resources.

In the end, the philosophy behind the success of social tagging is another application of what Raymond called the bazaar model, while describing the methodology behind the development of the kernel Linux in his classic "The Cathedral and the Bazaar" (2001), summarized as "with enough eyeballs, all bugs are shallow." Another example of application of the bazaar model in KO is the evaluation of the development model of the Open Shelves Classification (Martínez-Ávila 2012b, 344-72), "a free, 'humble,' modern, open-source, crowd-sourced replacement for the Dewey Decimal System" (Spalding 2008) developed by the LibraryThing community. Indeed, as O'Reilly also pointed out, much of the success of the Web 2.0 collaborative model owes a lot to the free software, open source technologies and philosophies such as the GNU licenses and Creative Commons.

Because of the remarkable success of many collaborative projects such as Wikipedia, many wanted to see in Web 2.0 the triumph of the human "social" organization over the machine artificial intelligence, the latter sometimes exemplified in the Semantic Web in spite of Berners-Lee's efforts of taking distance from it. Indeed, the dichotomy of Web 2.0 and Semantic Web might have been seen as the dichotomy of the publication of unstructured data and structured data, and, as the history of the Web seemed to be showing, the chaotic and unprofessional, but human organization of contents was winning.

However, despite all the achievements of Web 2.0, it also has to be recognized that many of the applications of knowledge organization in Web 2.0 are far from being perfect. As some authors (Agarwal 2012) have pointed out, one of the most obvious problems with Web 2.0 is that if anybody can create contents then anybody can destroy contents, as well as infringe copyright and privacy issues in a more anonymous way. In a more controversial paper, Doctorow (2001) also listed some possible causes for poor metadata generation by users: people lie in a competitive world, common people are too lazy to do something they do not understand, people refuse to exercise care and diligence in their metadata creation, people do not know themselves, schemata are not neutral, metrics influence results, and there is more than one way to describe something. However, as in the case of any social system, the problems of metadata misbehavior are not only related to the degree of civility of each individual, but also to their professionalism and theoretical training in KO, and the knowledge field in which tagging is being applied. Even assuming that users are generating metadata with their best intentions, the difference between good metadata and bad metadata might lie in the level of expertise and knowledge of the KO literature of those who are doing the "KO" work. As for the technical part, in order to be helpful, information has not only to be shared in a structured way, but also in a meaningful way, so machines can take advantage of the structure. Related to the problems of the Web and the misuse of metadata, since 2005 many have claimed for a combination of both Web 2.0 and Semantic Web features in order to improve the characteristics of the Web (see for instance Hope et al. 2007; Gruber 2007; El-Goarany et al. 2008; Greaves and Mika 2008; Jeschke et al. 2008; Durville and Gandon 2009; García Marco 2009, 2010a, 2010b; Lemen 2010; Casanovas 2012), sometimes including artificial intelligence elements too.

5.0 Linked (open) data

However, from Berners-Lee's point of view, the approach of combining Web 2.0 and the Semantic Web is perhaps misleading, since he never believed that the Web 2.0 was something different from the original Web, a web that was designed as a social tool from the beginning. In 2006 Berners-Lee stated that (Laningham 2006):

> Web 1.0 was all about connecting people. It was an interactive space, and I think Web 2.0 is, of course, a piece of jargon, nobody even knows what it means. If Web 2.0 for you is blogs and wikis, then that is people to people. But that was what the Web was supposed to be all along. And in fact, you know, this Web 2.0, quote, it means using the standards which have been produced by all these people working on Web 1.0. It means using the document object model, it means for HTML and SVG, and so on. It's using HTTP, so it's building stuff using the Web standards, plus JavaScript, of course. So Web 2.0, for some people, it means moving some of the thinking client side so making it more immediate, but the idea of the Web as interaction between people is really what the Web is. That was what it was designed to be as a collaborative space where people can interact.

And it is also around this time when Berners-Lee emerged with a new concept, the linked data, what might be seen as the next step in the Semantic Web progression or just another attempt to clarify what the World Wide Web actually is (Berners-Lee 2006): "The Semantic Web isn't just about putting data on the web. It is about making links, so that a person or machine can explore the web of data. With linked data, when you have some of it, you can find other, related, data." For this, Berners-Lee provided four rules: 1) Use URIs as names for things, 2) Use HTTP URIs so that people can look up those names, and here Berners-Lee emphasizes that HTTP URIs are names (not addresses), 3) When someone looks up a URI, provide useful information, using the standards (RDF, SPARQL), that is to make it available and in a way that can be understood and processed by machines and others, and 4) Include links to other URIs, so that they can discover more things. In 2010, Tim Berners-Lee added the requirement of using legal mechanisms such as the GPL derived licenses (such as Creative Commons) to guarantee the free use of data, stating that "Linked Open Data (LOD) is Linked Data which is released under an open license, which does not impede its reuse for free."

The definitions of linked data and linked open data have brought fresh air to the Semantic Web and its technologies such as RDF, OWL and SKOS. Linked open data has also inspired some new projects such as linked open vocabularies (LOV), aimed to promote and provide access to vocabularies in the "cloud;" schema.org, a project developed by Google, Microsoft and Yahoo to provide Web publishers with a universal vocabulary to describe their pages using linked data; HIVE (Helping Interdisciplinary Vocabulary Engineering), a model and a system that supports automatic metadata generation by drawing descriptors from multiple simple knowledge organization system (SKOS)-encoded controlled vocabularies (Greenberg et al. 2011); and some other new AI approaches to linked data such as the *AAAI Spring Symposium on Linked Data Meets Artificial Intelligence* (http://www.foaf-project.org/events/linkedai), organized by Dan Brickley among others, and the activities on AI at the Open Data Institute, chaired by Nigel Shadbolt (Howard 2013). These initiatives give some space and circularity to the relationship between AI and the Semantic Web.

In the library field, with the advent of IT and the Web, traditional practices and formats such as MARC have also seen the need to renewal in order to share and reuse bibliographic information not only with other catalogers, but also with other applications and agents working on the Semantic Web. As IFLA stated in 1997 (IFLA Study Group on the Functional Requirements for Bibliographic Records 2009, 1), some of the key factors contributing to this change include "the introduction and ongoing development of automated systems for the creation and processing of bibliographic data, and the growth of large-scale databases, both national and international in scope, that contain records contributed and used by thousands of libraries participating in shared cataloguing programs." On the other hand, it has also been suggested that new challenges and catalysts for these changes include an increasing need to adapt cataloging codes and practices to the emergence of new forms of electronic publishing, and the advent of networked access to information resources. These points were written for the *Final report on Functional Requirements for Bibliographic Records* (*FRBR*), that is a proposition of an entity-relationship (ER) model to identify the entities, attributes and relationships in the bibliographic description and use processes. Here, it is worth noting that, although the principles behind the Semantic Web are not exactly the same as in the ER model, in words of Berners-Lee (Berners-Lee 1998b), they are indeed closely related. In this vein, another initiative in the bibliographic field is BIBFRAME (Miller et al. 2012), that is an attempt to migrate from MARC to the linked data environment while encouraging the creation of clearly identified entities and the use of machine-friendly identifiers that lend themselves to machine interpretation for those entities. Finally, another cited example of combination of bibliographic resources and linked data can be found on OCLC's activity with schema.org. Since 2012, OCLC has been adding schema.org based mark-up descriptions to WorldCat.org, as well as additional linkages among their bibliographic description and other linked data efforts in the authority community (such as VIAF) and subject taxonomy efforts (including FAST and the *Dewey Decimal Classification*). The intended outcome of this initiative is to make the information stored in Worldcat.org more meaningfully accessible to search engines.

6.0 Knowledge organization and the need of knowledge organization

Taylor and Joudrey, in the introduction of their manual *The Organization of Information* (2009), highlight the multiplicity of contexts in which there is a desire to organize information, stating that the only ones that they are discussing in their book are: libraries of all types, archives, museums, the Internet, digital libraries, information architecture, indexing and abstracting, records management and knowledge management. On the other hand, Hjørland (2012) has questioned the variety of terms designing this concept, studying the relation between information organization (IO), organization of information (OI), information architecture (IA) and knowledge organization (KO). Hjørland, who advocates for the term knowledge organization, also acknowledges that in spite of the title of Taylor's aforementioned book, she (11) "is a well-known author of a textbook in KO." Thus, it seems that despite the differences of the terms and uses of the different denominations (with different most cited authors, most cited journals/works, and most cited references for each), the multiplicity of contexts and ubiquity of the need of organizing knowledge might suggest a good niche with common research questions that might benefit from the theory and inquiry on knowledge organization.

Knowledge organization has been defined as (Smiraglia 2012a, 225) "the domain in which the order of knowledge is both the primary paradigm for scientific investigation and the primary application in the development of systems." This definition is inserted in the discourse of the International Society for Knowledge Organization (see Dahlberg 2006), and relies, among others, very much on Hjørland's (2009) concept theory. In practice, the areas in which the order of knowledge is at play is pretty much ubiquitous, including many of the information technologies. In fact, as Hjørland noted (2008, 99), KO is just one among many contemporary fields which tries to play a role in the future environments of communicating and exchanging knowledge, although also pointing out that it is "important for each field to develop a clear identity and a history of its own." In the thesis of this paper, the historical role and possibilities of KO in information technologies have been overlooked and this has been indeed detrimental for its identity.

Making an analogy with the field of artificial intelligence (AI), perhaps the reticence of drawing on KO in some IT contexts might be caused by its own past, past setbacks in the case of artificial intelligence, and the limited reminiscence of traditional brick and mortar librarianship in the case of KO. Although it has been reported (see Markoff 2005) that some computer scientists and software engineers have deliberately adopted other names and avoided the term artificial intelligence for fear of being viewed as "wild-eyed dreamers," as some authors (Kurzweil 2005) have pointed out, the truth is that the bases of artificial intelligence underlie in many of today's technologies even when it is not recognized. As Bostrom (2006) once reported, "A lot of cutting edge AI has filtered into general applications, often without being called AI because once something becomes useful enough and common enough it's not labelled AI anymore." These arguments can be applied to KO too. Since some of these labels and terms have acquired enough relevance to become new fields on their own, such as informatics, knowledge-based systems, cognitive systems, intelligent agents, information architecture, knowledge management and more, one might wonder how much of the KO theory and principles have filtered into IT without naming it and perhaps lack of formal recognition.

For instance, Rowley and Harlton (2008) listed the following systems that employ approaches to KO in the digital environment:

- OPACs, that are libraries' online public access catalogs.
- Digital libraries, that are sets of electronic resources and associated technical capabilities for creating, searching and using information.
- Institutional and subject repositories, which provide access to digital objects that have been deposited with them; search engines and directories, that facilitate information retrieval in the Internet.
- Databases of abstracts and indexes and citation indexes, that are subject- or mission-specific bibliographic databases which record the publications within the discipline of the mission area and make them available for future searching.
- Content management systems, that enable users to develop and manage websites or other means of publishing, enabling the handling of text, images and multimedia information objects.
- Records management systems, that are concerned with the identification, capture, storage, retrieval and (where necessary) the destruction of records.
- Image retrieval systems.
- Wikis and blogs.

All these systems employ approaches to KO in conjunction with other areas such as information retrieval, information architecture, archival science and more.

7.0 Concluding remarks

In addition to these initiatives, there are many other aspects in which KO experts and theories might be very useful and needed. Some of these aspects are related to the premise that human intelligence is still ahead of AI, and, in spite of its complexities, ahead of the social component of the Semantic Web. Some of these challenges for KO in the intersection with IT include:

1) Assignment of terms.

Machines are not yet very good at identifying the aboutness of information resources without human intervention. Automatic classification and indexing techniques using probabilistic and linguistic approaches, such as in AI, have not been proved to be very accurate. On the other hand, as Hjørland (2011) has pointed out, humans' classification might be as unfruitful as machine's if they use the same theories of knowledge. Thus, education in theories and the philosophical foundation of IS are important not only for the human processes of indexing and classification, but also for the design and development of automatic tools of assignment.

2) Aligning vocabularies.

Although many of the old AI problems of merging databases and making vocabularies interoperable have been solved in part with Semantic Web standards (when people are willing to adopt them), there are still some problems related to the alignment of vocabularies. According to Schreiber (2011), some aspects in which research on this area is needed include: representation basis, need for established base of published vocabularies, alignment problems, and enrichment of metadata. As Takeda (2015) reported on his experience building core common vocabularies, the problems of core vocabularies are: misunderstanding, mismatching, "missing links" across different domains, and the gap between humans and machines, also concluding that simple mapping is not easy and a "more flexible framework is needed."

3) Evaluation and design of systems.

In practice, it is common to hear complaints about how hard it is to use systems and how vendors do not listen to users. For good communication with vendors (when that is possible) and the development of systems, it is important to know the specific and desirable KO features that the systems should be able to have, and the possibilities and limitations of IT to implement those features. On the other hand, education in the theory of systems design (e.g., Brooks 1995; 2010; Raymond 2001) and the philosophies that underlie systems might be even more fruitful.

4) Domain analysis.

Although the term "domain analysis" has been used in computer science (e.g., Neighbors 1980) to describe the activity of identifying the objects and operations of a class of similar systems in a particular problem domain, it was with the introduction of the concept in information science (Hjørland and Albrechtsen 1995) that became one of the most fundamentals theories in IS, also providing the basis for practical applications. As Richard Smiraglia (2012b, 111) puts it, "domain analysis is at the heart of knowledge organization, for without it we would have no ontological matter to constitute our knowledge organization systems (KOS)." As for its relationship with artificial intelligence, although Hjørland (2002, 449) has presented it as one of the eleven approaches to domain analysis in information science, he also stated that the fields of AI and cognitive sciences have historically been related to and dominated by individualistic rather than social ways of thinking. There are many different kinds of investigations into how researchers, experts and ordinary people think in and about different domains of knowledge. Some of this research is related to the attempt to build expert systems with artificial intelligence. Such research has mostly been done with a mechanical view of human thinking, neglecting the historical and cultural aspects of human cognition.

It should be noted that cognitivism in IS has been proved to be flawed and inapplicable in a globalized, culturally diverse, and ever-more connected world. As Hjørland reported elsewhere (2011, 77), "since approximately 1990 the cognitive view has increasingly been challenged by researchers such as Jack Andersen, Bernd Frohmann, Birger Hjørland, Jens-Erik Mai, Sanna Talja, and others, suggesting more social and interpretative approaches to IS." In the same way universal ontologies are not viable in practice, because of the impossibility of inferring the thoughts and meanings of few individuals to the global population, research on AI might benefit from the domain-analytic theoretical approach in order to improve specific applications.

5) Social tagging.

One of the problems with social tagging and folksonomies is sometimes the poor quality of the metadata. In some cases, this happens because social taggers do not know about the subject of the object they are tagging, and, in some other cases, when tagging is done by subject specialists, because they might not know about KO principles. On the other hand, some might be tempted to claim that if IT allows everybody to organize information in an easy way, then KO training and theory might not be needed at all. Concerning this, Hjørland (2006) commented on the professional competencies of LIS professionals compared to laymen and subject specialists that:

> Perhaps the dominating ideology within LIS is that LIS-professionals know how to use advanced technologies to organize knowledge, and that this is the main difference between laypeople and LIS-professionals. There is of course some truth in this, but the application of technology does not form the basis of science or intellectual field of study. Technology is just a tool. Knowledge Organization as a field of study is related to semantic theories, bibliographic theory and the like. If we, for example, consider a stamp collector, such a person may be more knowledgeable about relevant information sources and how to organize them than a LIS-professional. One idea about the difference between laymen and subject specialists on the one side and LIS professionals on the other side is that laymen and subject specialists are experts in a narrow field from which they may broaden their competencies. In other words: They are working bottom-up. LIS-professionals, on the other hand are working top-down: They start with knowledge about broad interdisciplinary information sources such as, for example, national bibliographies and citation indexes. From this point of departure, they specialize as far as they can.

It is important to have more than mere subject knowledge or IT skills to do the KO work. There is a whole outcome of research and theories in KO (many of them from the humanities and social sciences) that can help solve many of the current problems with social tagging and other collaborative practices.

6) Sociological aspects and ethical commitment.

The following pessimistic view on the Semantic Web was written by Cairo and quoted at the Third International Conference on Intelligent Systems Modelling and Simulation, in 2012 (cited by Agarwal):

> The Semantic Web will never work because it depends on businesses working together, on them cooperating. We are talking about the most conservative bunch of people in the world, people who believe in greed and cut-throat business ethics, people who would steal one another's property if it weren't nailed down. The people who designed the Semantic Web never read their epistemology (the part of philosophy that is about the study of how we know things) texts. But the big

> problem is they believed everyone would work together: - would agree on web standards - would adopt a common vocabulary - would reliably expose their APIs so anyone could use them.

There is some truth about this, we cannot force others to use and adopt standards, but when critical training in KO is provided (see for instance Olson 1997; García-Gutiérrez and Martínez-Ávila 2014), people can contribute with meaningful data in such a way that minimizes the problems of standards and addresses cultural issues. On the other hand, the library field, which KO is very often associated with, does not always reflect the greedy behaviors of the commercial interests that are presented in the quote. For instance, as it was pointed out in the BIBFRAME report developed by the Library of Congress in 2012 (Miller et al., 15): "The annotation approach of BIBFRAME is key to creating a system driven by the knowledge capacity of libraries rather than the commercial interests that presently dominate the Web." Subversive techniques within the standards, such as annotations and scope and local notes (e.g., Olson 2000; 2001; Hogan 2010), combined with a good contextual, ethical and theoretical knowledge of the communities to be represented, can help KO professionals to counterbalance the harmful interests of the market. This is why KO experts must have not only a good training in standards and IT, but also awareness of ethical and cultural issues. The ethical, cultural, and sociological aspects of communication were key aspects in the development of technologies in the past, and might still be the point where many challenges and opportunities for the intersection of KO and IT lie in the future.

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