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SEMANTIC WEB AND LINKED (OPEN) DATA POSSIBILITIES AND PROSPECTS FOR LIBRARIES

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Abstract
One of the recent topics in librarianship is the application of Semantic Web and Linked (Open) Data technologies for the purpose of library metadata management. The first part of this paper gives an overview of the basic principles and models of the Semantic Web (XML, RDF, URI, ontologies etc.), as well as the current usage of these principles in libraries and other cultural institutions, with main accent on the usage within Europeana, so called European digital library, archive and museum. The second part of the paper looks at Linked (Open) Data as a constituent and indispensable part of the Semantic Web. In addition to the main principles, it states the key advantages of publication of library matadata as Linked (Open) Data for the institutions as well as for the users. Also, some of the initiatives that have made such efforts are listed. Finally, the recommendation is given for reconsidering library practice in purpose of service improvements and better visibility of library data.

Keywords
Semantic Web, Linked (Open) Data, metadata, ontology, URI

1.Introduction

Even before Internet existed, librarians had made efforts to facilitate the search and browsing through the library catalogues for their users. With the invention of the Machine Readable Cataloging format (MARC) in the end of ’60 and the International Standard for Bibliographic Description (ISBD) in the beginning of ’70 of the XX century, transition from the paper to automated catalogue started (McCallum 2002). Since then libraries have progressed and today it is possible to search through many library collections in the World through services for integrated catalogue search, such as WorldCat or COBISS.NET.

In order to provide services of the integrated catalogue search, librarians had to achieve the interoperability of the metadata standards. These standards (so called metadata encoding schemas) are made with the intention of inter-institutional metadata sharing, therefore enabling this integrated catalogue search (Fox 2001). In the library world, UNIMARC, MARC and Dublin Core are the examples of such standards. The exponential growth of the resources and digital collections published on the Internet was accompanied with the development of the large number of metadata schemas, each of them based on the requirements of the different user profiles, communities, material types, project types, subject ranges etc. Still, the complete metadata interoperability has not been achieved yet. The main problem with building large digital libraries or metadata repositories emerges because of the non-standardized description, especially in small institutions (Chan and Zeng 2006).

Still, even with this problem which is the first step in achieving metadata interoperability, LIS professionals and researchers have been working for a while on achieving semantic interoperability, which is interconnection of the resources which originate not only from library resources, but from various cultural, scientific and other related institutions. This work is being done with the goal of making research of a certain topic easier. In such case, user does not have to know the exact type of a material carrying certain information, institution that it is its holder as well as different procedures for usage and search these institutions may have. Furthermore, the ultimate goal is to enable integrated search that would group all the related cultural-heritage material, which will be further connected to the relevant Web resources. This scenario is feasible through services available on the Internet, and with technologies Semantic Web is based on, as well as its application Linked (Open) Data. This paper tends to describe in which way the aforementioned technologies work, and how the library profession could improve with their implementation.

2.Semantic interoperability

Discipline called Knowledge Representation deals with the issue of the semantic interoperability. This discipline deals with key problems of the information society: How to construct and preserve the information and how to find and retrieve it in the most precise and effective way? (Weller 2010).

Except for assigning so called formal or bibliographic metadata, there is a well-established practice of classification and categorization in librarianship. Within this practice, unit is assigned a subject heading (a content-descriptive key word) or is being placed in one of the classification schemas (Cleveland and Cleveland 2001). Knowledge Organisation Systems-KOS were developed and used for document and collection organisation, in order to facilitate their retrieval.

Depending on the content, structure and the way of organisation, these terminological resources can be: term lists (authority files, glossaries, dictionaries etc), classifications and categories (subject headings, clasification and categorisation schemas, taxonomies), relationship lists (thesauri, semantic networks and ontologies). These systems can have the role of controlled vocabularies. They can define relations in which certain concepts can be found (mainly hierarhy or other sematic relations). The more sematic relations the system has, the more complex it gets in its structure (Hoge 2000).

Along with harmonization of the KOSs maintained by various institutions, it is possible to establish semantic metadata interoperability. One of the potential solutions for achieving this semantic interoperability is by harnessing the principles upon which Semantic Web is based.

3.Semantic Web

The vison of the Semantic Web was formulated by the World Wide Web (WWW) creator Tim Berners-Lee back in 1994, at the first WWW conference (Shadbolt et al. 2006). Berners-Lee envisioned the Web to be semantic, or as he defines it "web of data", and not "web of documents", as it is today. Berners-Lee is still one of the most prominent proponents of this vision, only now he is supported by large number of scientists and professionals from various areas.

Semantic Web offers the possibility of elevating the mechanisms for information discovery to a "semantic level", where a more sophisticated description of document is possible and the shared understanding between the user and the service provider can be reached via the exchange of ontologies, which provide the necessary vocabulary for a dialogue (Fensel at al. 2005).

Often called Web 3.0, the Semantic Web should enable machine interpretation of the knowledge contained in data, and not only of the raw data, in processes similar to human deductive reasoning. To make this feasible, condition is to have large amount of the publicly available data in standardized format. (Republički zavod za statistiku)

3.1Containing parts of the Semantic Web

The best known illustration of the Semantic Web is Semantic Web Layer Cake, Image 1), which depicts parts-layers of the Semantic Web, which will be shortly presented in the following text.

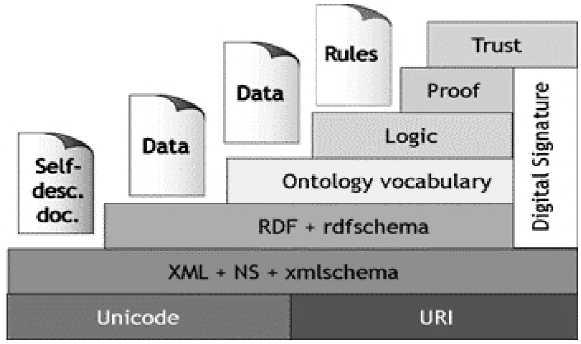

Image 1: Semantic Web Layer Cake, layers which Semantic Web technology is based upon (Miller 2001)

XML presents the syntactic layer and it is a meta-language that allows users to define labels for their documents by using tags. NS or Namespaces state from which set of elements certain XML tag is, for example <dc:title> is a tag for labeling Title of a resource from the Dublin Core metadata standard, that consists of elements for the description of the wide range of Web resources. Still, XML is not a means for expressing semantics (meaning) of the data. For these purposes Resource Description Framework- RDF is used. Using RDF, resources can be described by semantically meaningful links. The structured information of any resource is shaped as a simple statement, which is in the form of a triple: subject, predicate and object (RDF example).

An example of the RDF triple can be:

<ex:besnilo>,<ex:has_autor>,<ex:borislav_pekic>, describing the book Besnilo.

In addition to the statement, other two fundamental concepts of RDF are resources and properties. Resources are „things" we want to talk about, and in a statement they can be subject, predicate and object.

Uniform Resource Identifiers- URIs are used for the resource identification. Main property of an URI is that each one is globally unique and different persons and institutions can define them for the purpose of resource identification (Doerr at al. 2010)

Properties are special type of resources that are used for describing relations in which other resources can be found. Properties can be of various types, e.g. „has author", „has publisher", „has title" etc. and always are in the role of predicate in a statement. Object of one statement can be subject of another, therefore RDF enables presentation of simple statements in the form of a graph, in which subjects and predicates represent the nodes that are linked by arcs - properties. While property always has to be an URI, node of the RDF graph can be a string, or a blank node (in case when it does not have a form and identification outside of local graph, which is not a recommended practice) or URI (RDF example).

Image 2 presents an example of RDF graph, describing work „The chronicle of Čarnojević" (original title „Дневник о Чарнојевићу") (ex:001). The author of this work (URI for Miloš Crnjanski from the Virtual International Authority Files, VIAF database) and the date when the work was created (string 1921) are expressed using dcterms properties. Also, it shows two manifestations of this work (according to Functional Requirements for Bibliographic Records vocabulary), out of which one is a book published in 1993 and the other is an audio book published in 2012. With adding simple statements, theoretically this graph could expend infinitely, until all the relevant information is recorded.

Furthermore, languages such as RDF schema (Image 1, third row) allow defining vocabularies that can be used in statements. (RDF primer) All of the resources described this way can have a type. Subjects and objects of a statement can be declared to be instances of a certain class, which defines their type (e.g. pr:22809820 and pr:19126780 can be declared as instances of a class called Bibliographic resource). Moreover, mutual relations (properties) can be assigned by declarations of limitations and rules for the classes belonging to a certain knowledge area. Those relations between classes are defined with ontologies.

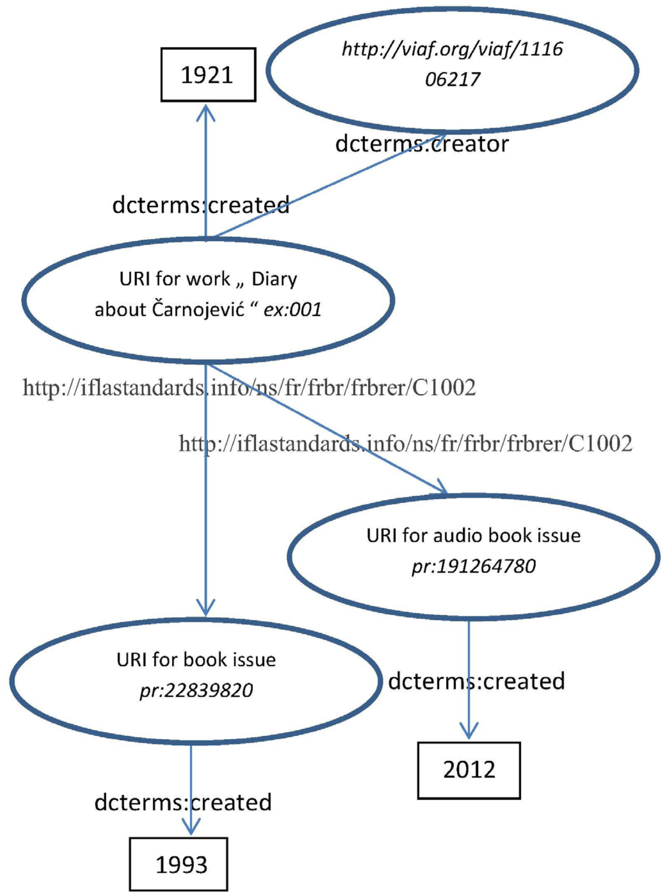

Image 2: Example of a description of a work and its two issues

3.2Ontologies

The most used definition for ontology (in a computer science, and not in its original philosophical sense) is the one by Gruber defining it as a "specification of a conceptualization"(Gruber 1993). More precisely, "ontology is a formal, explicit specification of a shared conceptualization. A 'conceptualization' refers to an abstract model of some phenomenon in the world which identifies relevant concepts of that phenomenon. 'Explicit' means that the type of concepts used, and the constraints on their use are explicitly defined. 'Formal' refers to the fact that the ontology should be machine readable, which excludes natural language. 'Shared' reflects the notion that an ontology captures consensual knowledge, that is, it is not private to some individual, but accepted by a group. ” (Studer et al. 1998).

Ontologies are usually defined by aforementioned RDF schema (RDFS) and Web Ontology Language- OWL. Different languages are developed for the purpose of querying RDF data, and the most used one is SPARQL (Simple Protocol and RDF Query Language), that allows more complex queries than its predecessor SQL. Furthermore, automatic reasoners are analyzing the structure and statements of the ontology's descriptive logic and infer information that is not entered directly. Therefore, based on explicitly coded knowledge, it is possible to infer new, implicit knowledge (Gomez-Perez et al. 2003).

From the data structured this way it would be possible to elicit information for an analysis of e.g. frequency of publishing of Miloš Crnjanski's work while he was in emigration. The example of such query could be: give me the information of the average number of years in which issue of the work pr:001 was published from the first issue to 1941 (the year of his emigration), then from 1941 until 1965 (during his emigration) and finally since 1965 until today (after the emigration).

4.Application in libraries and other institutions of culture

Ontologies are recognized as one of the most comprehensive systems for the description of the material that represents cultural, historical and scientific heritage, simply because they allow so called conceptual approach. Currently, there are several vocabularies-ontologies that can be used for the purpose of bibliographic description (Dublin Core, BIBO, ISBD, RDA, FRBR etc) and usualy they are used for the purposes of digital libraries.

Representative example of such ontology usage is Europeana Data Model (EDM), developed for the purposes ofEuropeana , European digital library, museum and archive. The motive behind creation of such model was to enhance the metadata interoperability of the formats used in various cultural-heritage institutions, while maintaining the richness of the original format of the legacy institutions. Authors of EDM decribe this model as a higher level ontology, general in its structure, but which allows the possibility of being extended with more specified ontologies that cover particular domains (archival, library, museum, audio-visual collections etc). EDM contains already existing vocabularies-ontologies (Dublin Core, SKOS etc). Except for the technical metadata interoperability, vision behind implementation of this new model in Europeana is the possibility of the rich semantic conceptualization for descriptions of objects in its database (counting about 25 million at present), in order to enable performing of more complex operations.

Another well known ontology is Simple Knowledge Classification System (SKOS), Web standard for thesauri repesentation in RDF (Doerr at al. 2010). Because of the well-established practice of controlled vocabularies usage in libraries, this standard is used among other things for connecting semantically equivalent concepts from different controlled vocabularies by means of skos:exactMatch property. Europeana uses SKOS in order to build semantical layer on top of the metadata in order to connect related material from different institutions. Still, the fact is that many institutions that are data contributors to Europeana do not use controlled vocabularies, which makes this whole process more complicated or limited (Olensky 2010).

Still, these technologies are more used in museums. This is because ontologies allow not only object-centered description but also the event-centric description, and information related to events of object's discovery or its usage is important information that needs to be appropriately recorded. The most used ontology made for the purpose of museum material description is CIDOC-Conceptual Reference Model (CIDOC-CRM).

Professionals working on the topic of information access facilitation, gathered around Europeana and related projects, believe that it is possible to link resources streaming from various cultural-heritage institutions by harmonization of their controlled vocabularies, but also by systematical linking to the resources available as a Linked (Open) Data-LOD, which is going to be described in further text. Europeana with new model EDM tends to „enrich" harvested metadata by linking to LOD. This linking process consists of placing URIs from LOD in the according description element-field, instead of its original value, which is usually a string. For example, author names can be replaced by URI from the VIAF database, which is unification of the author authority files from 16 libraries, and geographical locations can be replaced with links from GeoNames data base of geographical locations, that consist of much more data about certain geo-location then the simple name label is.

5.Linked (Open) Data

As already mentioned, Semantic Web was envisioned to be the Web of Data. Still, in order for this to become reality it is necessary first to have large amount of data in standard format published on the Web, so it can be processed with thechnologies which Semantic Web is based upon. Moreover, in order to establish such a web, it is necessary for this data to be in certain inter-relation, unlike regular data sets. This data base of inter-linked data sets on the Web is called Linked Data, or Linked Open Data (so called by Open Access movement proponents) and is a set of technologies and standards that make Semantic Web possible. This initiative came from World Wide Web (W3) consortium and its focus is to link data on the Web in order to semantically enrich it (Јурић 2011). The term of Linked (Open) Data refers to the set of best practice examples or principles for publishing and inter-relating structured data on the Web. These principles were set by Tim Berners-Lee in the "Linked Data" paper:

1. Use URIs as names for things
2. Use HTTP URIs so that people can look those names up
3. When someone looks an URI up, she/he should provide some useful information about it, using the standards already defined (RDF, SPARQL)
4. Include links to other URIs, so that users can discover more things (Berners-Lee 2006)

Usage of URIs in Linked (Open) Data is analogous to the usage of identifiers for authority control in traditional librarianship. URI can be Universal Resource Locator-URL, International Resource Identification-IRI or any other type of unique identifier (Antoniou and Van Harmelen 2008).

Term "cloud" is frequently used with the Linked (Open) Data term (so called LOD cloud). This LOD cloud is graphically presented as a diagram of inter-linked data sets. Number of data sets in the cloud has grown so much that probably soon all the data sets won't fit into one graph, while DBpedia remains the biggest set in the cloud. DBpedia is a public initiative in which structural data is extracted from Wikipedia in order to enable more complex querying. DBpedia is currently in its 3.7 version and describes 3.64 million "things", out of which 1.83 million is classified with a consistent ontology.

It is important to underline that Linked

(Open) Data connects structured data, and this is exactly what libraries have at their disposal - large amounts of well structured and rich data related to certain human knowledge sources. For this reason, libraries present one of the richest fields for implementation of the Linked (Open) Data technology. This fact was recognized by W3 consortium, which patrons a working group named Library Linked Data Incubator Group. It was founded in in May 2010 by several prestigious international institutions and it gathers community interested in library metadata and LOD, with the goal of making a report that would "increase global interoperability of library data on the Web" (Baker at al. 2010). This report was published in October 2011, and the following text is an excerpt- the first part of this document. It states advantages of publishing library metadata as LOD in order to illustrate the importance of taking the next steps in this direction by librarians.

5.1 Advantages of the Linked Data approach

The Linked Data approach offers significant advantages over current practices for creating and delivering library data while providing a natural extension to the collaborative sharing models historically employed by libraries. Linked Data and especially Linked Open Data is **sharable**, **extensible**, and easily **re-usable**. It supports multilingual functionality for data and user services, such as the labeling of concepts identified by language-agnostic URIs. These characteristics are inherent in the Linked Data standards and are supported by the use of Web-friendly identifiers for data and concepts. Resources can be described in collaboration with other libraries and linked to data contributed by other communities or even by individuals. Like the linking that takes place today between Web documents, Linked Data allows anyone to contribute unique expertise in a form that can be reused and recombined with the expertise of others. The use of identifiers allows diverse descriptions to refer to the same thing. Through rich linkages with complementary data from trusted sources, libraries can increase the value of their own data beyond the sum of their sources taken individually.

By using globally unique identifiers to designate works, places, people, events, subjects, and other objects or concepts of interest, libraries will allow resources to be cited across a broad range of data sources and thus make their metadata descriptions more richly accessible. The Internet's Domain Name System assures stability and trust by putting these identifiers into a regulated and well-understood ownership and maintenance context. This notion is fully compatible with the long-term mandate of libraries. Libraries, and memory institutions generally, are in a unique position to provide trusted metadata for resources of long-term cultural importance as data on the Web.

Another powerful outcome of the reuse of these unique identifiers is that it allows data providers to contribute portions of their data as statements. In our current document-based ecosystem, data is exchanged always in the form of entire records, each of which is presumed to be a complete description. Conversely, in a graph-based ecosystem an organization can supply individual statements about a resource, and all statements provided about a particular uniquely identified resource can be aggregated into a global graph. For example, one library could contribute their country's national bibliography number for a resource, while another might supply a translated title. Library services could accept these statements from outside sources much as they do today when ingesting images of book covers. In a Linked Data ecosystem, there is literally no contribution too small — an attribute that makes it possible for important connections to come from previously unknown sources.

Library authority data for names and subjects will help reduce redundancy of bibliographic descriptions on the Web by clearly identifying key entities that are shared across Linked Data. This will also aid the reduction of redundancy of metadata representing library holdings.

5.2 Benefits to researchers, students and patrons

It may not be obvious to users of library and cultural institution services when Linked Data is being employed because the changes will lie "under the hood." As the underlying structured data becomes more richly linked, however, the user may notice improved capabilities for discovering and using data. Navigation across library and non-library information resources will become more sophisticated. Integrated searches will improve through the use of links to expand indexes, and users will have a richer set of pathways for browsing.

Linked Data builds on the defining feature of the Web: browsable links (URIs) spanning a seamless information space. Just as the totality of Web pages and websites is available as a whole to users and applications, the totality of datasets using RDF and URIs presents itself as a global information graph that users and applications can seamlessly browse by resolving trails of URI links ("following one's nose") — a data-powered form of "toURIsm." The value of Linked Data for library users derives from these basic navigation principles. Links between libraries and non-library services such as Wikipedia, GeoNames, MusicBrainz, the BBC, and The New York Times will connect local collections into the larger universe of information on the Web.

Linked Data is not about creating a different Web, but rather about enhancing the Web through the addition of structured data. This structured data, expressed using technologies such as RDF in Attributes (RDFa) and microdata, plays a role in the crawling and relevancy algorithms of search engines and social networks, and will provide a way for libraries to enhance their visibility through search engine optimization (SEO). Structured data embedded in HTML pages will also facilitate the re-use of library data in services to information seekers: citation management can be made as simple as cutting and pasting URIs. Automating the retrieval of citations from Linked Data or creating links from Web resources to library resources will mean that library data will be fully integrated into research documents and bibliographies. Linked Data will favour interdisciplinary research by enriching knowledge through linking among multiple domain-specific knowledge bases.

5.3 Benefits to organizations

By promoting a bottom-up approach to data publishing, Linked Data creates an opportunity for libraries to improve the value proposition of describing their assets. The traditional top-down approach of assigning library metadata — i.e., producing catalogue records as stand-alone descriptions for library material — has been enforced by budget limits: libraries do not have the resources needed to produce information at a higher level of granularity. With Linked Data, different kinds of data about the same asset can be produced in a decentralized way by different actors, then aggregated into a single graph.

Linked Data technology can help organizations to improve their internal data maintenance processes and maintain better links between, for instance, digitized objects and their descriptions. It can improve data publishing processes within organizations even where data is not entirely open. Whereas today's library technology is specific to library data formats and provided by an Integrated Library System industry specific to libraries, libraries will be able to use mainstream solutions for managing Linked Data. Adoption of mainstream Linked Data technology could give libraries a wider choice of vendors, and the use of standard Linked Data formats would allow libraries to recruit from and interact with a larger pool of developers.

Linked Data may be a first step towards a "cloud-based" approach to managing cultural information, which could be more cost-effective than stand-alone systems in institutions. This approach could make it possible for small institutions or individual projects to make themselves more visible and connected while reducing infrastructure costs.

With Linked Open Data, libraries can increase their presence on the Web, where most information seekers can be found. The focus on identifiers allows descriptions to be tailored to specific communities such as museums, archives, galleries, and audiovisual archives. The openness of data is more an opportunity than a threat. Clarification of the licensing conditions of descriptive metadata facilitates its reuse and improves institutional visibility. Data thus exposed will be put to unexpected uses, as in the proverb: “The coolest thing to do to your data will be thought of by someone else.”

5.4 Benefits to librarians, archivists, and curators

The use of the Web and Web-based identifiers will make up-to-date resource descriptions directly citable by catalogers. The use of shared identifiers will allow them to pull together descriptions for resources outside their domain environment, across all cultural heritage datasets, and even from the Web at large. Catalogers will be able to concentrate their effort on their domain of local expertise, rather than having to re-create existing descriptions that have been already elaborated by others.

History shows that all technologies are transient, and the history of information technology suggests that specific data formats are especially short-lived. Linked Data describes the meaning of data ("semantics") separately from specific data structures ("syntax" or "formats"), with the result that Linked Data retains its meaning across changes of format. In this sense, Linked Data is more durable and robust than metadata formats that depend on a particular data structure (W3C Incubator Group 2011).

6.Conclusion

Although all of this may sound as a distant future and science fiction, actually many libraries did recognise the potential and have already implemented this technology to their data. Number of such projects is growing exponenially. Therefore, the future is here!

Europeana has published arround 3.5 million records as Linked (Open) Data, out of which are some coming from doiSerbia, service maintained by the National Library of Serbia. Data from Swedish union catalogue LIBRIS with around 6 million bibliographic records from 175 libraries were published by means of vocabularies such as FOAF (Friend of a Friend), SKOS, BIBI and Dublin Core. In this catalogue URIs are assigned to each unit and the records are further linked to LOD resources from DBPedia and Library of Congress Subject Headings-LCSH. Similar initiatives are happening in the majority of larger libraries e.g. in the Congress Library, the British Library, French, Hungarian and many other national libraries. In addition to the aforementioned VIAF project, some of the vocabularies available as LOD are: Dewey’s Decimal Classification, LCSH, French National Library Subject Headings-REAMEU etc.

Students, even the faculty staff would rather start their information searching on Google than in library, said Thomas Baker, president of the Dublin Core Metadata Initiative-DCMI. If libraries want to keep their role of the curators of the human intellectual production, their holdings have to be part of the Web and the initial search of our users (Kelley 2011).

Although a wider range of library professionals are still not familiar with this topic, certain number of professionals consider that it is crucial for the future of library profession to migrate their data outside of their institutional data bases (popular metaphor for those is "isolated data silos") into open, global surrounding in which the data is shared. Linking library metadata with those that are coming from other sources with LOD mechanism is considered to be a promising direction towards achieving stability, availability and reusability in the integrated web-based information universe. Also, it is considered that formatting and linking library metadata with RDF would make library content emerge on the surface of the Web searches, and make it available via Web protocols such as HTTP, instead of those made solely for library purpose, such as Z39.50 (Kelley 2011).

Since such initiatives have been taken by big libraries all around the world, we can conclude that this process has already begun and it is advisable for us to follow this example if we want to keep pace with the ever growing needs of the society. Still, in order to provide our users with the services they require, in addition to the initiative of librarians in establishing such a system, it is necessary to employ developers and information system engineers that will firstly understand the way of description in libraries and other cultural-heritage institutions, and then develop applications for the most optimal usage of these important and valuable data.

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Notes

1. http://dublincore.org/documents/dcmi-terms/
2. http://viaf.org/
3. http://www.ifla.org/publications/functional-requirements-for-bibliographic-records
4. http://europeana.eu/
5. http://www.geonames.org/
6. http://www.w3.org/
7. http://lod-cloud.net/
8. http://dbpedia.org/About

Text of the chapters 5.1-5.4 presents the excerpt from the document: W3C Incubator Group. 2011. Library Linked Data Incubator Group Final Report, chapters 2-2.4. http://www.w3.org/2005/Incubator/lld/XGR-lld-20111025/ (accessed on 24.VII 2013)

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