

# Semantic web based organization of scientific bibliography references

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**Abstract**— Scientific bibliographic references are of great significance for any scientific research as they provide valuable information important for the research being carried out. In order to effectively use references that can be quite numerous, collected over long time span by many researchers from various scientific fields, proper organization of references is required. Traditionally, an individual or a research group maintains a local reference collection statically indexed by one criterion, usually not compatible and connected with other similar lists maintained by other individuals or groups from the same or similar scientific field. This paper proposes and explains enhanced flexible organization of bibliography references based on semantic web standards that can provide for various views and searches of mutually compatible reference collections which can be easily combined and extended with other reference collections based on same standards across the web. For better illustration of benefits obtained by semantic representation of bibliography references, a small web application was implemented that enables remote user to access and view reference collections from various aspects useful for researchers. New functionalities, view and search capabilities can be added to application as required, without modifying semantic web reference collections.

**Key words**- Bibliography, references, semantic web, RDF, Ontology, SPARQL, search

## I. INTRODUCTION

Scientific research usually starts with insight into the current state of the research topic which is obtained by survey of the adequate scientific literature which can include various sources such as textbooks, journal and conference papers, dissertations, thesis and other scientifically refereed material. There are general, more heuristic than precise rules on how to obtain required relevant and significant literature for the research topic of interest. Today, the most important way of finding required information, including scientific, is using the great potentials of the contemporary ICT mainly in the form of various searches conducted by general search engines like Google, Yandex and others, using of specialized academic search services like Google Scholar, specialized scientific collections like arXiv<sup>1</sup> and NCBI<sup>2</sup>. Scientific journals offer various kinds of search for published papers. Depending on the degree of initial knowledge on research topic, search can be more or less specific. The less the initial knowledge, the more important is the general search for metadata like for instance search for scientific journals that cover the research topic.

<sup>1</sup> <http://arXiv.org>

<sup>2</sup> <http://www.ncbi.nlm.nih.gov>

Thomson Reuters<sup>3</sup> Master Journal List<sup>4</sup> is a good starting point for journal search. Less official search and informational methods can be based on personal contacts and similar. Scientific references can be collected over long time span from various sources, various research fields that is particularly the case with multi and inter disciplinary researches. Individually collected references from the point of view and specific interests of the researcher should be effectively added to reference collection that is shared and used by all research team members. References can also be shared among various research groups working on same or similar research. In order to be used effectively, large reference collections that may be collected by many individuals from various sources should be appropriately organized in order to be available, transparent and useful to every team member from each research group.

There are many existing contemporary systems for references management that can offer various functionalities such as reference storing, various views, search, remote access, sharing, and similar. Functionalities and services for reference management offered by those systems are usually available as web applications, desktop / mobile applications, or in the form of web browser extensions. Various reference management systems although different, usually have built in capabilities for connecting with other systems in the form of mechanisms for importing and exporting of references in various formats like BibTex and other text formats. Besides references, those management systems also support keeping of papers full text when available.

This paper emphasizes the complementary approach for reference management based on semantic web and open data principles [1, 2]. References as other kinds of publicly open data can be semantically structured according to standard semantic web ontologies [3] developed for the purpose of reference organization and management. Some journals like Semantic Web Journal<sup>5</sup> by IOS press<sup>6</sup> use the semantic web concepts during paper submission and reviewing procedure [4]. Publishing of references as open semantically structured data can have many benefits for various users as the source data are not hidden and accessible only through proprietary software systems with various imposed rules and limits, but are directly accessible in standard formats, semantically structured according to standard ontology developed for reference

<sup>3</sup> <http://thomsonreuters.com/en.html>

<sup>4</sup> <http://ip-science.thomsonreuters.com/mjl/>

<sup>5</sup> <http://www.semantic-web-journal.net/>

<sup>6</sup> <http://www.iospress.nl/>

management, which offers whole variety of views using standard semantic web tools, development of applications for required specific purposes, and easy linking of open data.

Following sections are organized in the following way: Chapter II lists some of the well-known systems that offer some kind of reference management with short descriptions; Chapter III discusses the semantic structuring of references based on existing standard ontologies for references; Chapter IV describes the structure of the proposed system for semantic based organization of references, Chapter V gives an overview of developed web application that uses semantic reference data, and Chapter VI is conclusion which gives paper overview and future work.

## II. SOME EXISTING REFERENCE MANAGEMENT SYSTEMS

Many existing systems help academics and researchers to organize their research work, with various installed functionalities for reference management as very important aspect of research work. All systems require creation of user account for identification and customization of virtual environment in the scope of existing functionalities which are considered as useful. Each registered user aids the creation of large searchable references collection that includes reference items entered by other users.

Mendeley<sup>7</sup> can import references from various sources and organize them online sorted in folders. Very important feature is search for scientific papers in various disciplines. Registered users can invite other users, search for other registered users and follow their work. Users groups with some common academic or scientific thematic can be created. There is also desktop application which is synchronized with online account and aids in collecting references from sources which are better accessible from the local computer.

BibBase<sup>8</sup> manages user references as a personalized publicly available web page with listed references that can be sorted and searched for by various criteria such as year, author, type, keywords and according to number of downloads. References can be imported in various ways, as BibTex entries, and also from other systems, like already mentioned Mendely and Zotero which will be mentioned. Users can browse and search for items entered by other registered users, such as reference entries, web pages, other users, by keywords, means of general search and listings ordered by popularity which is measured by number of visits.

ResearchGate<sup>9</sup> serves primarily for creation of a research network which connects registered users by paper co authorship and affiliation. It also uses member's skills and expertise as a criterion for posting research questions to competent members which are likely to provide an answer. Users are asked to confirm their own authorship on publications, and also to confirm authorship of others. If permissible, authors are asked and encouraged to upload whole papers in order to be available to other users. Publications of other members can be searched in various ways, such as

general search, recent publications, publications from user's network or publications from research field.

Zotero<sup>10</sup> combines user's virtual community and a handy versatile software tool which can be installed as a browser extension or as a standalone application with similar functionalities. Application can import various kinds of reference material as text and multimedia in various formats. All reference material is synchronized with online account which makes it both secure and available on many devices. One particular feature of Zotero which is available both online and from application is a reference exporting capability in various formats. Export formats which are of special interest for the rest of the paper from the aspect of semantic representation are following three formats: "Bibliontology RDF", "Dublin Core (CD) RDF" and "Zotero RDF" formats. RDF [5] (Resource Description Framework) is fundamental for representation of data on semantic web.

Google Scholar<sup>11</sup> "My Library" is a specialized Google search service for academic publications. Besides very famous search capabilities, for a registered user, Google Scholar offers "My Library" service for storing users publication found on Google Scholar. "My Library" is a sort of reference management system that collects user publications, provides annual histogram reference statistics and articles cited by the author.

KoBSON<sup>12</sup> is a Serbian National Library government supported project that provides full access to many worldwide journals, and has many useful academic services. One of the services is providing complete reference lists of papers published in journals with impact factor, for a selected author. Some other very useful services are search among extensive list of international journals with services for full access, annual historical data for selected journals impact factor, list of libraries with journal paper copies with designated starting year of subscription, and other.

Besides other sources, all mentioned systems that in some way support remote reference management influenced up to a point the idea for semantic based reference management system described in the remainder of the paper. However, the most important are KoBSON that served as the source of quality uniform references in BibTex format that were imported in Zotero web browser extension, and exported in RDF format. Once the references are in some RDF format, web application relying on SPARQL [6] processor<sup>13 14</sup> can quite easily obtain majority of described functionalities with publicly available open data based on some of the RDF formats, like RDF/XML [7] or Turtle [8] as the most common RDF formats.

## III. STANDARD ONTOLOGIES FOR REFERENCES

Publishing of open data for semantic web relies on structuring data according to appropriate ontology that can describe knowledge for the context of data being published and

<sup>7</sup> <https://www.mendeley.com/>

<sup>8</sup> <http://bibbase.org/>

<sup>9</sup> <http://www.researchgate.net/>

<sup>10</sup> <https://www.zotero.org/>

<sup>11</sup> <http://scholar.google.com/>

<sup>12</sup> <http://kobson.nb.rs>

<sup>13</sup> Jena Fuseki <http://jena.apache.org/index.html>

<sup>14</sup> DotNetRDF <http://www.dotnetrdf.org/>

presented. In order to present open data in a standard way, existing standard ontologies and vocabularies should be used in the first place. If according to the best knowledge such ontology is not known, the new specific ontology is developed in order to adequately represent data and to enable various required specific views of data using the SPARQL queries by any interested party. New ontologies are developed using the OWL [9] and existing other appropriate ontologies and vocabularies. While both vocabularies and ontologies are represented as RDF, vocabularies define basic notions - terms and properties, and ontologies describe knowledge structure by various relationships and constraints.

For describing bibliography references, standard ontologies [10, 11] exist. The main ideas and significance of semantic publishing are based on original ideas and recommendations by Tim Berners Lee [12].

The Bibliographic Ontology<sup>15</sup> (BO) [13] was developed with the aim of describing bibliographic references for semantic web. It relies on standard vocabularies such as DC<sup>16</sup> (Dublin Core) and FOAF<sup>17</sup>. BO is used by Zotero for exporting references into RDF format.

The Semantic Publishing and Referencing Ontologies (SPAR)<sup>18</sup> [14] consists of eight component ontologies which are independent and can be used independently or in any combination for complete required description of various bibliographic entities.

The Zotero RDF used by Zotero online, web browser extension and standalone application for conversion of reference data to RDF from some of the textual reference formats, like BibTex, was actually used for web application presented in this paper. It was intentionally selected among other

LISTING 1 EXAMPLE OF REFERENCE IN BIBTEX

```
@ARTICLE{
  author={Srecko R Trifunovic and Zoran D
  Matovic and V Milovanovic and H Kawaguchi and M
  Yamasaki},
  year={2000},
  title={Manganese(II) complexes with edta-type
  ligands. The molecular structure of aquo-
  dihydrogen(1,2-propanediamine-N,N,N',N'-
  tetraacetate)manganese(II) trihydrate, [Mn(H(2)1,2-
  pda)(H2O)] center dot 3H(2)O},
  journal={TRANSITION METAL CHEMISTRY},
  volume={25},
  number={6},
  pages={680-685},
  document_type={Article},
}
```

alternatives for test purposes, as the BO is actually recommended<sup>19</sup> as preferable to Zotero RDF.

#### IV. SEMANTIC ORGANIZATION OF REFERENCES

Bibliographic references as a significant component of scientific research should be available in an appropriate form for required review. As the most appropriate form is not the same for various review requirements, reference collection should be available in various forms depending on required review and use. Large reference collections can be reviewed and searched chronologically, by journal, by author, by group of authors, by keyword or by some other specific request that can also be some combination of the mentioned. In order to achieve that, reference collection should be presented in a form flexible enough. Additional requirement is that reference source data, or reference data in "raw form" should be publicly available for creation of updated application that will provide required specific view of references in a standard way. Semantic web ontology based structure of references can provide for all stated requirements and can even provide for additional quality of integration with other reference collections with same semantic structure.

As stated earlier, a number of reliable uniform references were downloaded from KoBSON repository source reference in BibTex format. References from KoBSON in BibTex format organized according to principal authors were imported in Zotero web browser plug in reference management application. Using the Zotero application built in exporting capabilities, the files in Zotero RDF were created for each principal author. The notion of principal author indicates that all references in one RDF file have that author as one of the coauthors. Conversion from BibTex to RDF can be treated as equivalent from the aspect of data which are the same in both formats. But, although the data are the same, and both formats are textual, directly visible in plain text editor, RDF format has advantage that it can be queried by SPARQL query engine even as plain text file available from the web server. Listing 1 shows a reference in BibTex format.

Every RDF document has heading with XML namespaces (xmlns) used for identification of resources, shown in listing 2. In the remainder of RDF document are definitions of resources, the references data, with example given in listing 3.

LISTING 2 RDF HEADING

```
<rdf:RDF
  xmlns:rdf="http://www.w3.org/1999/02/22-rdf-
  syntax-ns#"
  xmlns:z="http://www.zotero.org/namespaces/export#"
  "
  xmlns:dcterms="http://purl.org/dc/terms/"
  xmlns:dc="http://purl.org/dc/elements/1.1/"
  xmlns:prism="http://prismstandard.org/namespac
  es/1.2/basic/"
  xmlns:bib="http://purl.org/net/biblio#"
  xmlns:foaf="http://xmlns.com/foaf/0.1/">
```

<sup>15</sup> <http://bibliontology.com/>

<sup>16</sup> <http://dublincore.org/documents/dcmi-terms/>

<sup>17</sup> <http://www.foaf-project.org/>

<sup>18</sup> <http://sempublishing.sourceforge.net/>

<sup>19</sup> Simon May 31st 2013 on page:

<https://forums.zotero.org/discussion/29807/zotero-rdf-documentation/>

LISTING 3 REFERENCE IN RDF

```
<bib:Article rdf:about="#item_202">
<z:itemType>journalArticle</z:itemType>
<dcterms:isPartOf>
<bib:Journal>
<dc:title>TRANSITION METAL CHEMISTRY </dc:title>
<prism:volume>25</prism:volume>
<prism:number>6</prism:number>
</bib:Journal>
</dcterms:isPartOf>
<bib:authors>
<rdf:Seq>
<rdf:li>
<foaf:Person>
<foaf:surname>Trifunovic</foaf:surname>
<foaf:givenname>SreckoR.</foaf:givenname>
</foaf:Person>
</rdf:li><rdf:li>
<foaf:Person>
<foaf:surname>Matovic</foaf:surname>
<foaf:givenname>Zoran D.</foaf:givenname>
</foaf:Person>
</rdf:li><rdf:li>
<foaf:Person>
<foaf:surname>Milovanovic</foaf:surname>
<foaf:givenname>V.</foaf:givenname>
</foaf:Person>
</rdf:li><rdf:li>
<foaf:Person>
<foaf:surname>Kawaguchi</foaf:surname>
<foaf:givenname>H.</foaf:givenname>
</foaf:Person>
</rdf:li><rdf:li>
<foaf:Person>
<foaf:surname>Yamasaki</foaf:surname>
<foaf:givenname>M.</foaf:givenname>
</foaf:Person>
</rdf:li>
</rdf:Seq>
</bib:authors>
<dc:title>Manganese(II) complexes with edta-
type ligands. The molecular structure of aquo-
dihydrogen(1,2-propanediamine-N,N,N',N''-
tetraacetate)manganese(II) trihydrate,
[Mn(H(2)1,2-pdta)(H2O)] center dot
3H(2)O</dc:title>
<bib:pages>680-685</bib:pages>
<dc:date>2000</dc:date>
</bib:Article>
```

LISTING 4 SPARQL QUERY FOR ALL REFERENCES

```
prefix bib: <http://purl.org/net/biblio#>
prefix dc: <http://purl.org/dc/elements/1.1/>
prefix z:
<http://www.zotero.org/namespaces/export#>
prefix dcterms: <http://purl.org/dc/terms/>
prefix prism:
<http://prismstandard.org/namespaces/1.2/basic/
>
prefix rdf: <http://www.w3.org/1999/02/22-rdf-
syntax-ns#>
prefix foaf: <http://xmlns.com/foaf/0.1/>
prefix fn: <http://www.w3.org/2005/xpath-
functions#>
select distinct ?Paper ?Authors ?Type ?Journal
?Volume ?No ?Year ?Pages
from
<http://physics.kg.ac.rs/physics/TrifunovicSrec
koRCorrected.rdf>
where{?a a bib:Article.
optional {?a dc:title ?Paper}
optional {?a z:itemType ?Type}
optional {?a dc:date ?Year}
optional {?a bib:pages ?Pages}
?a dcterms:isPartOf ?x.
?x a bib:Journal;
optional {?x dc:title ?Journal}
optional {?x prism:volume ?Volume}
optional {?x prism:number ?No}
{select distinct ?a (group_concat (distinct
?FullName; separator = ", ") as ?Authors)
where{select ?a ?FullName
where{?a a bib:Article;
bib:authors [a rdf:Seq;
?b [a foaf:Person;
foaf:givenname ?Name;
foaf:surname ?Surname]].
let(?FullName :=fn:concat(?Name, " ",
?Surname))}
order by ?b
}}
group by ?a
}}
order by ?Year
```

## V. WEB APPLICATION FOR REFERENCES REVIEW

Developed web application is purely client oriented without component working on server, excluding SPARQL processor.

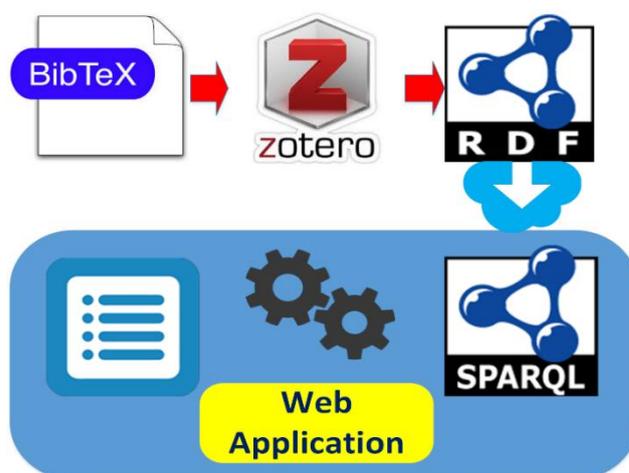


Figure 1 Web application architecture

RDF listings 2 and 3 are in RDF/XML syntax. Whole RDF file with many other references is publicly accessible at the address: <http://physics.kg.ac.rs/references/TrifunovicSreckoRCorrected.rdf>

Once the references are in RDF format, many various views of reference data can be obtained by SPARQL queries from SPARQL processors. SPARQL query in listing 4 gives complete listing of all references with SPARQL processor at the address: <http://147.91.205.66:2020/sparql.html>

Instead of SPARQL processor at the upper address, some other could be used as well. More RDF files with references from various web addresses can be merged as SPARQL source by adding <from> clauses in SPARQL query. In order to create user interface for easy selecting of various reviews web application was created that illustrates some of the capabilities for various reviews of semantically structured reference collection.

**Semantic references Principal author: Srecko R. Trifunovic**

Principal authors list | Authors | Journals

**Extensive authors list**

Raza Murad Ghalib

Publications for selected author | Co authors for selected author | Journals for selected author

PapersNo | 2 |

**SPARQLer Query Results**

Paper	Authors	Type	Journal	Year	Volume	No	Pages
"Isolation and Crystal Structure Determination of 3,5,4'-Trihydroxy-6,7-Dimethoxy-Flavone (Eupalitin) from <i>Asparagus falcatus</i> (Linn.)"	"Raza Murad Ghalib, Sayed Hasan Mehdi, Rokiah Hashim, Othman Sulaiman, Arto Valkonen, Kari Rissanen, Srecko R. Trifunovic"	"journalArticle"	"JOURNAL OF CHEMICAL CRYSTALLOGRAPHY"	"2010"	"40"	"6"	"510-513"
"A novel caryophyllene type sesquiterpene lactone from <i>Asparagus falcatus</i> (Linn.); Structure elucidation and anti-angiogenic activity on HUVECs"	"Raza Murad Ghalib, Rokiah Hashim, Othman Sulaiman, Sayed Hasan Mehdi, Arto Valkonen, Kari Rissanen, Srecko R. Trifunovic, Mohamed Ahamed, Amin Majid, Fumio Kawamura"	"journalArticle"	"EUROPEAN JOURNAL OF MEDICINAL CHEMISTRY"	"2012"	"47"		"601-607"

Figure 2 Publications for selected author

Its purpose is to enable user remote web access for selection of various reference reviews and filtering. All functionality is implemented in JavaScript which sends parametric SPARQL queries to SPARQL processor, and displays generated result. General architecture of web application is presented in Fig. 1. References prepared in BibTex format are converted by Zotero application to RDF in RDF/XML syntax. RDF files generated by Zotero are publicly available at web server folder with web address: <http://physics.kg.ac.rs/references>

The same web address is also used to start web application from `index.htm` file. RDF file names follow simple template:

`<SurnameNameFirstnameMiddlenameLetterCorrected.rdf>`

Names in template correspond to principal author's names that can be selected in web application from drop down list under "Principal authors list" tab. For selected principal author, various reference views and filtering are available under tabs "Authors" and "Journals" as can be seen in Fig 2, which shows "Publications for selected author" which is a coauthor of currently selected principal author whose name is written at the top of the web page. All coauthors including currently selected principal author can be selected from "Extensive authors list: drop down list shown in Fig 2. Other two views available under "Authors" tab are "Coauthors for selected author" and "Journals for selected author". Views are activated by corresponding buttons with descriptive text. Under "Journals"

tab there is a drop down list "Extensive journal list" which includes all journals for selected principal author. The two views are currently available corresponding to journals, "Journals" which gives all journals with number of papers, and "Papers for selected journal" which lists papers for selected journal as shown in Fig 3 for a different principal author than in Fig 2.

Web application illustrates the potential of references semantic structuring. When converted to RDF, each element of every reference item becomes available for search, filtering, display, grouping, sorting and indexing thus offering virtually unlimited possibilities for required reference management. References "raw" data are publicly available in standard plain text files which can be referenced by SPARQL queries from any Internet enabled location.

## VI. CONCLUSION

Semantic structuring of scientific bibliographic references proposed in this paper is based on semantic web standards and open data assumption. Although there are many existing online reference management systems, main advantages of proposed semantic open data alternative for reference management are public availability of data in plain text raw format, great

**Semantic references Principal author: Snezana D. Markovic**

Principal authors list | Authors | Journals

**Extensive journals list**

ARCHIVES OF BIOLOGICAL SCIENCES

Journals | Papers for selected journal

PapersNo  
4

**SPARQLer Query Results**

Paper	Authors	Year	Volume	No	Pages
"Time course of hematological parameters in bleeding-induced anemia"	"Mihajlo B.Spasic, Zorica S.Saicic, Andras S.Stajin, Branka I.Ognjanovic, Natasa Z.Djordjevic, Marijana P.Milosevic, Snezana D.Markovic"	"2009"	"61"	"2"	"165-170"
"Effects Of Cisplatin On Lipid Peroxidation And The Glutathione Redox Status In The Liver Of Male Rats: The Protective Role Of Selenium"	"Zorica S.Saicic, Jelena P.Gavric, Andras S.Stajin, Snezana D.Markovic, Natasa Z.Djordjevic, Branka I.Ognjanovic, Ivana S.Trbojevic"	"2010"	"62"	"1"	"75-82"
"Glutathione Status in the Blood of Rats After Reticulocytosis Induced by Phenylhydrazine and Bleeding"	"Mihajlo B.Spasic, Zorica S.Saicic, Andras S.Stajin, Branka I.Ognjanovic, Jovana B.Zizic, Ana D.Obradovic, Snezana D.Markovic"	"2010"	"62"	"3"	"589-594"
"Alteration of Oxidative Stress Parameters in Red Blood Cells of Rats After Chronic in Vivo Treatment with Cisplatin and Selenium"	"Andras S.Stajin, Branka I.Ognjanovic, Natasa Z.Djordjevic, Danijela M.Cvetkovic, Milena G.Curcic, Ana D.Obradovic, Dragana S.Djadic, Jovana B.Zizic, Snezana D.Markovic"	"2011"	"63"	"4"	"991-999"

Figure 3 Papers for selected journal

potential for development of various views and required specific user customization using SPARQL query language, integration with other distributed reference collections or other semantic based systems for research support. Future work will be towards integration with semantic web systems for research support.

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