Developing and Maintaining a WordNet: Procedures and Tools

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Abstract

In this paper we present a set of tools that will help developers of wordnets not only to increase the number of synsets but also to ensure their quality, thus preventing it to become obsolete too soon. We discuss where the dangers lay in a WordNet production and how they were faced in the case of the Serbian WordNet. Developed tools fall in two categories: first are tools for upgrade, cleaning and validation that produce a clean, up-to-date WordNet, while second category consists of tools gathered in a Web application that enable search, development and maintenance of a WordNet. The basic functions of this application are presented: XML support and import/export facilities, creation of new synsets, connection to the Princeton WordNet, sophisticated search possibilities and navigation, production of a WordNet statistics and safety procedures. Some of presented tools were developed specifically for Serbian, while majority of them is adaptable and can be used for wordnets of other languages.

1 Introduction

Development of a WordNet is always a labor-intensive task for which a work of a number of professionals is needed. If produced from the scratch and mostly manually the development will necessarily take many years if aiming at comprehensiveness and accuracy. In such a setting a valuable resource, not yet fully developed, can easily become obsolete. The reasons for this are manifold. First, since WordNet is dealing with "words", its contents can become out-of-date. A straightforward example can be found in the Princeton WordNet 3.0 (PWN): it describes *Yugoslavia* as the Union of Serbia and Montenegro (which no longer exists) while *Serbia* is described as a historical region in central and northern Yugoslavia, and not as a Republic (which it is today). Moreover, new items can be added to a WordNet content, like domain information or similar. Next, the format used to represent a WordNet necessarily changes and evolves in time. The early wordnets did not use XML representation which is almost obligatory today. However, new, more powerful representations emerge. Tools used to develop and maintain wordnets have to keep pace with content enhancement and format changes. Finally, many wordnets were developed highly relying on the PWN by using a so-called *expand model* in which synsets from the PWN are translated into a target language (Fellbaum, 2010). Wordnets developed in this way are all connected through the Interlingual Index (ILI) that links similar concepts between languages, which is highly advantageous for various multilingual applications. However, in order to maintain this network a WordNet has to regularly upgrade when new versions of the Princeton WordNet emerge.

The Serbian WordNet faced all mentioned problems. The Serbian WordNet (SWN) was initially produced in the scope of the BalkaNet project (Stamou et al., 2002). At the end of the project, in 2004, the Serbian WordNet had 7,000 synsets linked to the Princeton WordNet version 2.0. In the subsequent years approximately 14,000 synsets were added to it thanks to volunteer work of numerous specialists and the WordNet editor. The addition was not done at random - as the need arose, special attention was given to certain conceptual domains - emotions - and scientific domains - biological species, biomedicine, religion, law, linguistics, literature, librarianship, computer science, and lately, culinary. Recently, a new impetus to the enhancement and upgrade of the SWN was given by the CESAR project, in the scope of which many Polish, Slovak, Hungarian, Croatian, Serbian and Bulgarian resources were thoroughly

described by meta-data and made public through the META-SHARE [1] repositories (Ogrodniczuk et al., 2012). The Serbian WordNet is available for download for non-commercial use under the CC-BY-NC license.

In the meantime, many new applications based on natural language processing were being developed for Serbian and for a number of them the Serbian WordNet became a valuable resource, e.g. for document classification systems (Pavlović-Lažetić and Graovac, 2010), multilingual queries into digital libraries (Stanković et al., 2012), multiword lexica acquisition (Krstev et al., 2010), domain specific knowledge-based ontologies and systems (Mladenović and Mitrović, 2013), etc. However, in order to profit from it as much as possible it became a necessity not only to upgrade and improve it but to establish a stable environment for its development in the future. The most important steps in this process were:

1) A safe and unequivocal mapping onto the current version of the Princeton WordNet (PWN 3.0);

2) A creation of XML Schema that would enable a thorough validation of the Serbian WordNet and automatic correction of many formal inconsistencies;

3) Mapping of Serbian WordNet to SUMO;

4) A conversion from XML format to other relevant formats.

In Section 2 we will present the present environment for the development of SWN and its limitations. In order to perform afore mentioned improvement tasks we have developed a number of preparatory tools that will be described in Subsection 3.1. Our job did not end here: in order to provide for a continuous development of the Serbian WordNet a web application that enables browsing for all and updating and enhancing of its content for a chosen set of specialists is being developed. We will present this tool in Subsection 3.2. In Section 4 we will give directions for future work.

2 Motivation and discussion

Serbian WordNet was structurally built following the pattern of EuroWordNet (Vossen, 1998), as was the case with other wordnets that were built in the scope of BalkaNet - wordnets for Bulgarian, Czech, Greek, Romanian and Turkish. XML-like representations of the EuroWordNet data were produced with a tool named VisDic (Horák and Smrž, 2004).

For many years VisDic has proved to be a reliable, user-friendly tool for development and maintenance of the SWN. It was particularly useful for simultaneous work on multiple WordNet XML documents of identical structure. The connection between those documents was achieved in two ways - through the AutoLookUp function, which connected the synsets of different WordNet files with the same synset identification, where their side-by-side representation was the result, and through the function CopyEntryTo which allowed for copying of the contents of a certain synset from one WordNet file into another. The search functionality of this tool leaned on the representation of synsets via a tree-structure in both directions (towards the root and towards the leaves). Two operations were implemented in that regard: TopmostEntries and FullExpansion. The first one provided all synsets that presented roots of the relational hierarchy. The second operation provided all synsets that represented the parts of a subtree in the given search. VisDic allowed for a certain degree of control over the consistency of data. It could point out to some inconsistencies such as synsets with identical IDs, duplicate Literal/Sense pairs or duplicate synset links.

In the first years of the development of the Serbian WordNet, VisDic, as a free tool, significantly contributed to the development of this semantic network. Still, the fact that it was limited to the desktop surrounding made team work difficult. This was particularly inappropriate for the development of the SWN, as a number of volunteers frequently worked simultaneously on its development (Krstev et al., 2008). Merging of parts of WordNet files made by many users into one file was always susceptible to introducing errors and inconsistencies. For that reason, the accessibility and usefulness of the WordNet editing tool needed to be improved. The resource itself did not allow for automatic processing of XML documents because the XML-like files used in VisDic did not have a root element. Furthermore, VisDic did not have a function for checking whether the input XML document was well-formed and/or valid against a DTD or XSD Schema. As a result, the structure of the Serbian WordNet was diverse from one synset to another. Moreover, due to the lack of validity control users were allowed to input un-

[1] http://www.meta-share.eu

supported as well as some unexpected tag values. The limited system of morphological labeling in VisDic did not serve well to the morphologically rich language such is Serbian. That is why morphological tags were manually added later, based on Serbian morphological electronic dictionaries. This information was added manually by the chief editor of the SWN inside the element LNOTE that was not specifically intended for this type of information. This method was susceptible to errors and slowed down the process of adding entries.

The same problem was present with adding SUMO tags to the synsets that were specifically present only in the Serbian WordNet, that is, they were not transferred from the PWN, like synsets with BILI tags, that is to say, synsets that were added in the course of the BalkaNet project, or those synsets that were specific to the Serbian language and carried the tag SRP. Also, developers of the SWN often felt that some other useful and often needed checking procedures were missing in VisDic, for instance check for hanging synsets (missing the hypernym relation). Also, it often occurred that some basic statistics had to be produced (number of synsets and literals per Part-of-Speech, number of multi-word literals vs. simple literals, literals with the highest number of senses, synsets with the highest number of literals, etc.). A number of scripts were written as needed to overcome this deficiency of VisDic.

Insufficient connection of VisDic with the SUMO (Pease, 2011) and other upper level ontologies, as well as with domain ontologies, slowed down the development of tools for ontological reasoning based on the Serbian WordNet. Also, the impossibility of transformation of the XML document to other formats, especially to RDF and OWL made the development of ontology-based knowledge bases related to WordNet even more difficult. Lastly, the search system of VisDic leaned on elementary queries over the content, without the possibility of setting logical filters or the possibility of smart search, e.g. the use of XPath. Taking into account all advantages and setbacks of the existing software solution, we took on the task of designing and building a set of tools that would improve the development of the Serbian WordNet and other semantic resources for the Serbian language.

3 Developing the Tools and the Web application for Semantic Resources for Serbian

The entire project aimed at enhancing the tools for developing, maintaining and using SWN was split into two phases: preparatory phase and operational phase.

3.1 Preparatory Phase

In this phase, we defined procedures and tools that enabled the following 6 tasks:

1. In the first step we created a software tool to upgrade the current version 2.0 of the SWN onto the version 3.0 of the PWN. This tool uses the mapping files produced and made available by The Center for Language and Speech Technologies and Applications at the Technical University of Catalunya [2]. to translate SynsetID from one PWN version to SynsetID of the other version of PWN (Daudé et al., 2003). In general, our software tool was created to transform every version of SWN to any other, as long as the appropriate mapping is available. For the cases of ambiguous or nonexistent mappings, the tool produced two additional files - a file `doubled` that lists pairs (or triples) of synset IDs in the version 3.0 that corresponded to one synset in version 2.0 (there was a total of 45 such synsets in SWN, version 2.0) and a file `missing` that lists IDs of synsets from version 2.0 that could not be mapped to the new version (a total of 147 synsets with this problem were retrieved in SWN version 2.0). All these cases were resolved manually.

2. In the second step we defined the `swn.xsd` Schema for validation and control of SWN. The first introduced XSD schema used for SWN is presented in (Krstev et al., 2004). A software tool LeXimir (the old name ILReMat) that used it, was created to work as a connection between VisDic and morphological dictionaries for Serbian. Still, functions for validation of the SWN as an XML resource were not implemented. Also, when the new tags had to be introduced in SWN (such as SNOTE - a note related to a synset, or SUMO - for SUMO concepts), the corresponding XSD schema did not follow those changes. Furthermore, the problem remained to distribute and install the new schema to all the desktop applications that would use it. Now, the new version of the SWN XSD schema (given in Figure 1) can be easily changed by SWN

[2] `http://bit.ly/18Uf8kX`

administrators, uploaded to the web server, made available to all other SWN users and maintained as a part of a web tool for on-line WordNet search, development and maintenance (presented in Section 3.2).

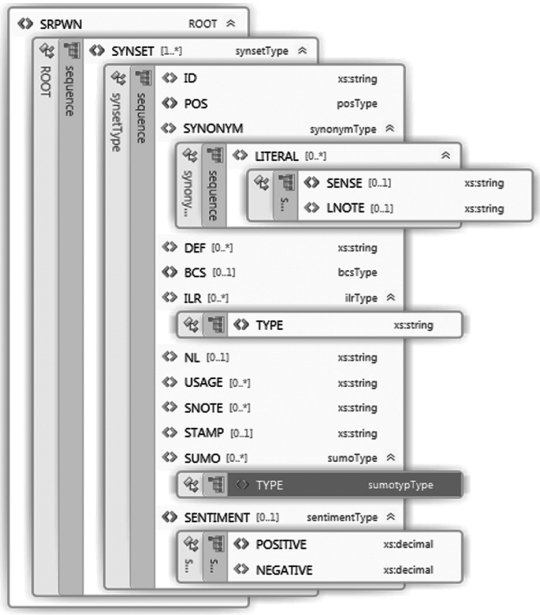

Figure 1: XSD schema for SWN XML

3. In the third step, a module was developed to validate and correct the SWN in its original VisDic XML-like representation (with the root element added) against the newly developed SWN XSD Schema. This module performed automatic correction in all unambiguous cases, such as rearrangement of elements, which represented the majority of cases. In the case of the last version of the SWN XML file a total of 17,994 POS tags, 6,110 BCS tags, 20,421 ILR tags, 130 BCS tags and 10 NL tags changed their position in the new WordNet XML document. For other types of errors, such as inappropriate or empty contents of elements an error report was issued and those errors were corrected manually. At the end, a well-formed and valid SWN was obtained.

4. This step is specific to the Serbian language. Namely, it uses two alphabets equally: Cyrillic and Latin. Translation from Cyrillic to Latin is straightforward since to each Cyrillic letter corresponds one Latin letter or digraph. The same is not valid for translation from Latin to Cyrillic because digraphs have to be distinguished from consonant groups. For instance, in *nadživeti* "outlive" dž represents a consonant group, while in *odžak* "chimney" dž is a digraph. When these two words are written in Cyrillic the problems do not exist anymore: надживети and оџак. When the development of the first Serbian language resource started back in early 80s it was still difficult to work with Cyrillic, especially if it was mixed with the Latin alphabet which normally happens in Serbian texts. For that reason a special encoding was invented that uses the ASCII character set and enables unambiguous mapping to both Serbian Cyrillic and Serbian Latin. Many valuable Serbian resources were developed using this encoding. Today, however, it is obsolete and we decided that it was time to switch to the Unicode UTF-8 for Serbian Cyrillic. This could not be done fully automatically because there are literals or parts of literals that have to remain in Latin script, e.g. names of biological species such as *породица Bovidae* "family Bovidae", chemical symbols and formulae, e.g. H2O and some acronyms, like PC for personal computer. In order to facilitate this process we have defined some simple rules that recognize instances that have to remain in the Latin alphabet. After automatic translation of SWN from ASCII to Unicode UTF-8 the SWN was checked by Serbian electronic dictionary and incorrect translations were corrected manually.

5. Serbian WordNet developed using VisDic did not contain the information about SUMO ontology. This information was indirectly available from the PWN through the alignment process. However, for one wishing to use the SWN outside the VisDic environment this information would be missing. We developed a separate module that explicitly assigns this information to synsets in the SWN. For synsets that were taken over from the PWN this was easily done. In SWN there are specific concepts: 530 Balkan specific concepts and 174 Serbian specific concepts. They were also appointed with SUMO tags. The procedure was carried out automatically, by inheriting the tag of the parent synset, if one existed and if it had a SUMO tag. After that, the rest of the mappings, that is to say the unresolved ones, were done manually.

6. In this step automatically are prepared some useful lists that help users that create new synsets by the new application to fill some elements with appropriate values. The first one is the list of all semantic relations that can be established between synsets. This list was obtained on the basis of all semantic relations that exist in PWN. The second one is the list of SUMO concepts con-

nected to the POS to which they apply. This list was obtained from existing SUMO tags in PWN (Niles and Pease, 2003). The third list is the list of all codes of inflectional paradigms for simple and multi-word units used in Serbian morphological e-dictionaries (Krstev, 2008). This list gives an example and short explanation beside each code that can help user to choose one when filling the appropriate element - LNOTE. For example (Table 1), the synset boat:1 from PWN has a corresponding synset barka:1, čamac:1, čun:1 in the SWN. The inflectional codes for these three literals are N664, N41 and N81, respectively. Entries for these three codes in the prepared list are (if these same literals were given as examples):

N664	*barka*	the dative singular *barci*
N41	*čamac*	fleeting a; the vocative singular *čamče*
N81	*čun*	the nominative plural *čunovi*

Table 1: Examples of inflectional codes used in SWN.

These three lists are used in a form of dropdown list in the web application for WordNet search, development and maintenance presented in the next section. The first two lists are of general nature, while the third one is specific to Serbian.

3.2 Operational Phase

In this phase, a web application was developed and its beta version was uploaded to the address: `http://resursi.mmiljana.com` The purpose of this application was to encompass all benefits of the already existing software tool, new demands of the Serbian semantic web users and contemporary software development techniques to enable a safe, efficient, multi-user, modular and easy to expand system for development of semantic resources in Serbian. In this phase, the following procedures and tasks were carried out.

1. A very important module of the web application is the XML validator. This module is able to validate any WordNet file against any XSD scheme and to obtain validation errors and suggestions for corrections. Also, it enables a serialization into TXT, CSV, RDF or XML formats with a chosen XSL transformation of a complete file or parts of search results. RDF representation is especially interesting to us because it can be queried and processed by standard Semantic Web tools, thus facilitating the integration of the WordNet data into various Semantic Web applications.

2. The web application was built in order to facilitate changing and adding of new synsets into wordnets. The new synsets can be added one at a time (either by transferring from the PWN - see item 3 - or independently) or as a batch. The latter case is particularly useful for addition of language specific concepts. The prepared synsets have to be in a valid XML form (except for a root element) with IDs of linked synsets already filled in appropriate elements. This method was used for enhancing the SWN with Serbian specific concepts from the culinary domain (Stanković et al., 2014). For synsets that are added one at a time, a form is prepared for filling obligatory and optional elements, while a user can open new fields for repeatable ones. In the case of SWN, the drop down lists that we described in the previous subsection were used to input the ILR, LNOTE and SUMO tags which were filtered automatically according to the POS.

3. Another segment of the application is the option of forming queries over the PWN resource in the version 3.0. For that purpose, we used the WordNetEngine [3] and we enhanced it with the functionality of copying of a chosen synset from the PWN into SWN. Search over the PWN can be carried out in two ways: by entering a word (in the Word field) or by entering an ID of a synset (in the synset ID field), in which case the POS must be chosen from the drop-down list given next to the synset ID field. If we choose the ID of a synset for the POS for which it does not exist, the program will notify us, otherwise it will provide a clickable link in order to display further details about semantic relations of that synset with other synsets. The number of shown semantic relations i.e. hierarchical representations of semantic relations of a particular synset with synsets semantically connected to it, is defined by checking the type of a semantic relation which we want to represent hierarchically using the check-box lists named Noun, Verb, Adjective and Adverb which contain labels of the most common semantic relations pertaining to the given POS.

4. The implemented search functions over the SWN take into consideration all tags from a WordNet used. If a user chooses a tag SYNSET, then a full-text search over a whole wordnet is per-

[3] `http://ptl.sys.virginia.edu/msg8u/NLP/Source/ResourceAPIs/WordNet/WordNet/`

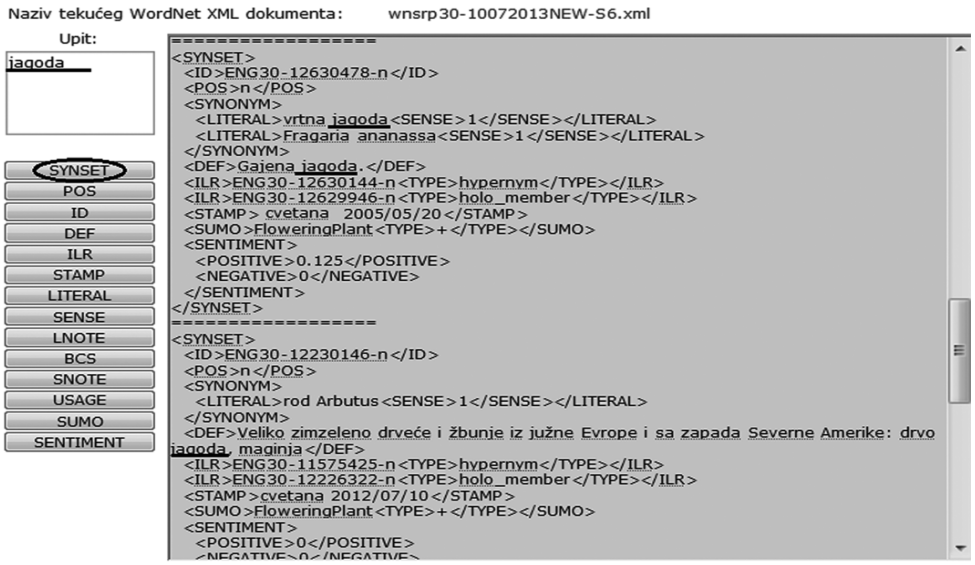

Figure 2: User-friendly XPATH queries over different SWN tags

formed. Also, they search data according to the authoring information. A search function can be either set to a simple value (Figure 2) or via a logic filter which is implemented to be user-friendly for those who are not familiar with XPath.

For example, the filter could be set to search for all synsets that have the term *jabuka* "apple" and whose SUMO tag is "PreparedFood" via an advanced logic query:

```
<SUMO> equals "PreparedFood" AND
(<LITERAL> contains "jabuka" OR
<DEF> contains "jabuka")
```

Or we could find all synsets whose part of a literal or a literal itself is also contained in the superior synset as is the case with synsets described by LITERALS *obrazovna ustanova* "educational institution", *verska ustanova* "religious institution", *medicinska ustanova* "medical institution" and their hypernym given by the LITERAL *ustanova* "institution".

Similarly, we could find: all antonym synsets for synsets which have a LITERAL tag that contains a word *ružan* "ugly". The result of an advanced logic query is a synset whose sense is *lep* "handsome".

```
(<LITERAL>contains "ružan" AND
<ILR><Type>equals "near_antonym")
```

All the query results can be displayed in textual (Figure 3) and graphical tree form. Tree representation facilitates navigation through the seman-

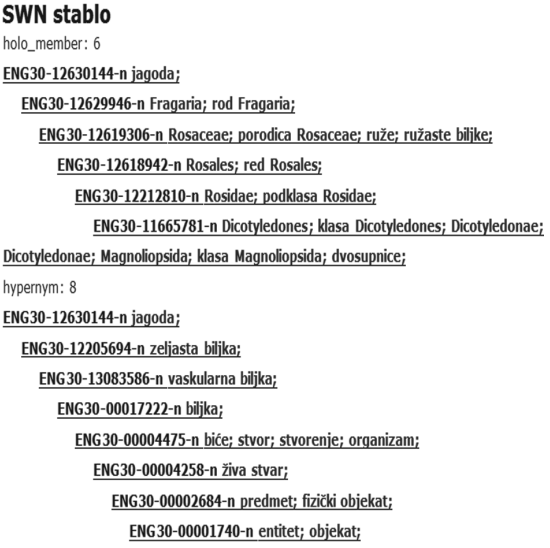

Figure 3: Semantic relations tree structure of a synset *jagoda* "strawberry"

tic relations tree structure because every synset in a tree representation is a link to the synset itself. The main purpose of textual form is its serialization as a subsegment of SWN structure to be used later as a resource in some other applications. For example: if we search for the term *osećanje* "feeling", as a result we obtain a semantic tree where the root synset has the sense of the searched term and the leaves are synsets representing emotional states. Such structure can be used as a separate XML file and mixed with other resources in the process of opinion mining tasks. A special submodule SWNengine is coded to imple-

ment all functions needed for navigation through the semantic relations tree structure of SWN.

5. Besides search functions over WordNet synsets, a separate module is created for providing statistical information about some valuable parameters of a WordNet in use that were often needed in the past. Table 2 shows some data provided by this module for the current version of SWN.

POS in Synsets					
POS	Noun	Verb	Adj.	Adv.	
Synsets	16978	2157	1584	121	
Inter Lingual Indexes in Synsets					
ILI	ENG	BILI	SRB		
Synsets	20136	530	174		
Semantic Relations in Synsets					
ILR	Hyper-nym	Holo part	Holo mem	Holo portion	
Synsets	19123	1746	3890	222	
ILR	Antonym	Derived	Derived gen	Derived pos	
Synsets	783	665	38	45	
Number of Literals in Synsets					
Literals	1	2	3	4	5
Synsets	11356	6657	1969	557	190

Table 2: Examples of inflectional codes used in SWN.

6. The safety of this application was ensured via roles and levels inside those roles. Roles are granted by WordNet administrators. The following roles were defined: unauthorized users that have the right of elementary querying over the network, using complex logic filters and statistical reporting about connections and meanings inside of the network itself; WordNet users and administrators. Inside of roles, the levels are defined - ordinary users that can input and change only the synsets which they themselves have defined, and moderators who have control over the entire resource. Tag NL holds the information about status of a synset. If the moderator has not yet verified all data concerning the newly inserted synset, NL tag is set to "no", and when the new synset has been approved by the moderator, the value of NL tag switches to "yes". Also, for the information about the "hanging" semantic relations (e.g. if one of synsets in the relation doesn't exist) is presented for each synset in the visual form.

The application is developed as ASP.NET Framework 4.0 C# web site, corresponding to the relational database MS SQL Server 2005 and by using jQuery 1.8.9 library at client's side. It is available for non-commercial use under the CC-BY-NC license.

4 Conclusion

The Serbian WordNet has a potential to develop with more substantial speed and quality now that valuable new tools for its usage and development are available. In this new tool we wanted to keep all characteristics of the old software VisDic that proved useful in the past and to add the missing ones of which the most important are a full XML support, distributed work, and advanced search. We have achieved this goal, but it should be noted that the interface is still under construction and its development will follow users' demands in future. Also, for the time being it is given in Serbian, but we plan to enable localization for other languages in the next phase.

We hope to continue the development of SWN in several directions. In the process of further extension of this resource, domain knowledge about agroindustry, medicine, geology etc. will be added, depending on the scientific fields in which it will be used. Sentiment labels for synsets and procedures of parallelization with English resources of the same purpose are also planned in the near future. Furthermore, we plan on increasing the number of noun-adverb relations in order to enrich the system of semantic relations and semantic knowledge that would facilitate tagging of rhetorical figures in Serbian. Finally, mapping to SUMO ontologies and generating of an appropriate ontology from the existing XML resource will be taken into consideration. We believe that wordnets developed for other languages can benefit from some of our tools, namely the tool for upgrading one version of WordNet to another, as well as other tools - with minor adjustments depending on the particular needs of the administrators and users of those wordnets.

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