GermaNet - representation, visualization, application

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Abstract

This paper outlines current developments centering around the lexical-semantic database GermaNet and its applicability both within language engineering tasks and on the Semantic Web. From this perspective, representation and standardization are considered to be crucial issues as regards compatibility and interoperability with other languages resources. Representation variants of lexical data, eg. XML-based formats, enable various web applications and data exchange. Furthermore, visualization tools for exploring ontologies can be adopted and enhanced.

1. Introduction

This paper discusses recent research on representing, standardizing and visualizing semantic wordnet resources, exemplifying the case for GermaNet[1], a lexical-semantic wordnet for the German language. Wordnets like the Princeton WordNet[2] have become popular and powerful resources for various natural language processing scenarios, supporting tasks in the fields of machine translation, information retrieval, semantic annotation and language tool development, among others. Several monolingual as well as polylingual wordnet initiatives have been launched, like EuroWordNet[3], Portuguese Wordnet, Balkanet.

As the rise of the Semantic Web has evolved an important research and application area, in which access to different ontologies plays a crucial role, it is worth developing XML-representations of wordnets in order to exploit their rich inherent semantic content. XML is a powerful and reliable standard, on which interfaces for numerous tools and tasks have been built, including a variety of query and visualization tools.

A common format for wordnet representations is useful and desirable in view of cross-lingual operability. Compatibility can be realized by comparing language-specific resources to Princeton WordNet, as we did for GermaNet (Lemnitzer & Kunze, 2002). A reliable standard also paves the way for its extension or merging with different resources. Visual exploration of lexicons and ontologies constitutes a further challenge, e.g. within the field of computer-aided language learning.

The article is structured as follows: In the next section, design principles and peculiarities of GermaNet as well as compatiblity issues to WordNet are briefly introduced. Section 3 presents the data model of GermaNet via an Entity-Relationship graph on which the XML conversion process was built. A further section (4) addresses issues of merging GermaNet with other lexical resources, extending the original DTDs. The last section describes on-going developments with regard to visualization tools which realize an on-line module for ontologies or parts of their structures.

2. A short outline of GermaNet

With GermaNet (Hamp & Feldweg, 1997; Kunze, 2001; Wagner & Kunze, 2001), a lexical-semantic wordnet for the most common and frequent concepts of the German language has been developed, which is structured along the lines of Princeton WordNet (Fellbaum, 1998). Though adopting the major properties and database technology from WordNet, GermaNet was built from scratch, accounting for some principle-based modifications.

The German wordnet, presently covering more than 40, 000 synsets with about 60, 000 word meanings, provides for the basic semantic relations holding among the lexical items like hyponymy, antonymy, meronymy, etc. 15, 000 selected GermaNet concepts have been integrated into the poly-lingual EuroWordNet database, in which wordnets for eight European languages have been correlated via an interlingual model (Vossen, 1999). This was done using the merge approach[4], i.e. the German synsets (already existing) were linked to the Interlingual Index by creating the appropriate equivalence relations.

GermaNet has become a valuable resource which is being used in academia and industries for research and applications within different fields of language technology and knowledge engineering.

Still there is need to further enrich the resource with additional features like semantic roles and further types of semantic relations. The number of interlingual links to the EuroWordNet database should also be significantly extended in order to support real-world tasks in cross-lingual applications.

Progress in these issues will profit from data representations which obey a well-defined underlying

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[1] GermaNet has been developed within the project "SLD: Ressourcen und Methoden zur semantisch-lexikalischen Disambiguierung", which was funded by the Ministery of Research of Baden-Württemberg in 1996-1997. A second period of funding has been granted in 1999-2001 (http://www.sfs.uni-tuebingen.de/lsd).

[2] Princeton WordNet (Miller (1990), Fellbaum (1998)) as the first in the field of wordnet construction has evolved as the quasi-standard (http://www.cogsci.princeton.edu/~wn).

[3] The EuroWordNet database has been built within two projects: EuroWordNet-1 (LE-4003) and EuroWordNet-2 (LE-4 8328), funded by the European Commission. The whole project was coordinated by Piek Vossen (http://www.hum.uva.nl/~ewn/).

[4] In contrast, some language-specific wordnets were integrated via the *expand approach*, in which WordNet synsets were translated into the language in question. Consequently, the relational structure was adopted and therefore highly biased by WordNet.

format and meet the requirements of a data encoding standard.

Both the construction of GermaNet and its integration into EuroWordNet have followed independent principles, thus resulting in structural differences to WordNet such as

- the use of non-lexicalized, so called artificial concepts in GermaNet for creating well-balanced taxonomies;
- choosing a taxonomical (GermaNet) versus sallelite approach (WordNet) for representing adjectives;
- the unified treatment of meronyms (GermaNet) instead of distinguishing three pointers for Part, Member and Substance (WordNet);
- cross-categorial encoding of causal relations (GermaNet), not only from verb to adjective (WordNet);
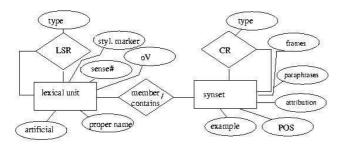- the employment of different and more specific subcategorization frames in GermaNet.

These differences have to be captured, if we are aiming at defining a unifiable data format for different wordnets and lexicons (cf. Lemnitzer & Kunze, 2002 for a broader discussion of this issue).

3. The data model

The data model of GermaNet is explicitly encoded in the database as well as in the lexicographer's files. It is not easy to access, though. Application programmes which should be coupled with this resource can not rely on standard tools for interfacing the data or for parsing and converting them into an appropriate format. We therefore aim to provide a clear view of the data structure to the users of GermaNet. Such a view is realized by two means: an Entity-Relationship graph and two Document Type Definitions (DTD).

3.1. Entity-Relationship graph

First, we represent the data structure by graphic means using the Entity-Relationship Model (Chen, 1976).

Fig. 1: Entity-Relationship graph of the GermaNet data model

From the graph in figure 1 we can easily deduce:

- the **objects**, synsets and lexical units, which are represented as *rectangles*,
- the **attributes** of these objects, represented as *circles*,
- the **relations**, represented as *diamonds*. In GermaNet, like in WordNet, we distinguish:

o **conceptual** relations (CR) which hold between instances of the synset object (e.g. hyperonymy) from
o **lexical-semantic** relations (LSR) which hold between instances of the lexical unit object (e.g. antonymy).

From an Entity-Relationship model, one can formally derive the conceptual structure of a relational database in a normalized form (Seesing, 1993). One can also, however not as unambiguously, derive a DTD or schema for an encoding of the data which is in line with the XML standard.

3.2. The DTDs

We will now present the GermaNet data as XML-encoded documents which conform to a set of two Document type definitions (DTDs). One DTD represents the objects (synsets and lexical units) and their attributes, the other represents the relations between these objects.

In the following, we will describe both DTDs. Note that we did not use the *XML schema* formalism to describe the objects. There are two reasons for this. First, we do not need the additional descriptive power which the XML schema language provides. Second, the DTD notation is much more compact and therefore easier to read.

The first DTD represents the data model of the objects and their attributes. It is recorded completely in fig. 2.

```
<!-- DTD for Germanet objects -->
<!-- Version 1.9, March 2002 -->>
<!-- Copyright: Sem. f. Sprachwissenschaft der
Universität Tübingen -->

<!ELEMENT synsets     (synset)+>
<!ELEMENT synset      ((lexUnit)+, attribution?,
frames?, paraphrases?, examples?)>
<!ATTLIST synset    id           ID    #REQUIRED
             wordClass       CDATA  #IMPLIED
             lexGroup        CDATA #IMPLIED>
<!ELEMENT lexUnit     (orthForm)+>
<!ATTLIST lexUnit    id           ID    #REQUIRED
         StilMarkierung (ja|nein)    "nein"
         sense CDATA          #REQUIRED
         orthVar      (ja|nein) "nein"
         artificial    (ja|nein) #REQUIRED
         Eigenname    (ja|nein) #REQUIRED >
<!ELEMENT orthForm    (#PCDATA)>
<!ELEMENT paraphrases  (paraphrase)+>
<!ELEMENT paraphrase   (#PCDATA)>
<!ELEMENT examples    (example)+>
<!ELEMENT example      (text, frame*)>
<!ELEMENT frames      (frame)+>
<!ELEMENT attribution  (#PCDATA)>
<!ELEMENT text         (#PCDATA)>
<!ELEMENT frame        (#PCDATA)>
```

Fig 2: The GermaNet objects DTD

Description: Documents which conform to this DTD contain a set of *synsets*. Every *synset* consists of at least one *lexical unit*. *Paraphrases* may be given to characterize the meaning of the synset and an *attribution* as well as *examples* may be added to illustrate the use of its member

lexical units. For verb synsets, subcategorization *frames* are given. The individual lexical units are characterized by a set of attributes, e.g. *sense* number and stylistic marker (*StilMarkierung*). A concept can be represented by a string which does not correspond to a lexical unit in the German vocabulary. Such a unit will be marked as *artificial*. The content model of most atomic elements is set to *#PCDATA*, therefore minimizing data type restrictions. It is up to the lexicographers to fill the elements with appropriate data.

```
<!-- DTD for GermaNet relation files.-->
<!-- Version 1.4, März 2002 -->>
<!-- Copyright: Sem. f. Sprachwissenschaft der
Universität Tübingen -->

<!ELEMENT relations (lex_rel | con_rel)+>
<!ELEMENT lex_rel (locator+, arc+)>
<!ATTLIST lex_rel name (antonymy | pertonymy |
participleOf) #REQUIRED
            dir (one | both) #REQUIRED
            sense        CDATA #REQUIRED
            xmlns:xlink CDATA #FIXED
'http://www.w3.org/1999/xlink'
            xlink:type (extended) #FIXED 'extended'>
<!ELEMENT con_rel (locator+, arc+)>
<!ATTLIST con_rel name (hyperonymy | meronymy |
holonymy | entailment | causation | association)
#REQUIRED
            dir (one | both) #REQUIRED
            xmlns:xlink CDATA #FIXED
'http://www.w3.org/1999/xlink'
            xlink:type (extended) #FIXED 'extended'>
<!ELEMENT locator EMPTY>
<!ATTLIST locator xlink:type (locator) #FIXED 'locator'
            xlink:href CDATA #REQUIRED
            xlink:label CDATA #REQUIRED>

<!ELEMENT arc EMPTY>
<!ATTLIST arc xlink:type (arc) #FIXED 'arc'
        xlink:from CDATA #REQUIRED
        xlink:to CDATA #REQUIRED
        xlink:actuate (onRequest) #FIXED 'onRequest'
        xlink:show (other) #FIXED 'other'>
```

Fig. 3: The GermaNet relations DTD

Description: Documents which conform to this DTD contain a set of relations which are either conceptual or lexical relations. These relations are characterized by their type (attribute: name) and they are marked as either symmetrical or directed (attribute: dir). They are realized as links according to the XLink specification: a link consists of two nodes (locators, specified through the IDs of the synsets or lexical units) and one or two arcs, depending on whether the relation is directed or symmetrical. The attributes of the 'arc' element specifies the processual behaviour whenever a link is traversed.

3.3. Example data

The following two examples serve to illustrate the XML format of the data (fig. 4 and 5). The first example presents two synsets, the second example two relations.

```
<synset id="nZeit.91" lexGroup="Zeit"
wordClass="nomen">
<lexUnit Eigenname="nein" artificial="nein"
id="nZeit.91.Anfang" orthVar="nein" sense="1"
stilMarkierung="nein"> <orthForm>Anfang</orthForm>
</lexUnit>
<lexUnit Eigenname="nein" artificial="nein"
id="nZeit.91.Beginn" orthVar="nein" sense="1"
stilMarkierung="nein"> <orthForm>Beginn</orthForm>
</lexUnit>
<lexUnit Eigenname="nein" artificial="nein"
id="nZeit.91.Anbeginn" orthVar="nein" sense="1"
stilMarkierung="ja"> <orthForm>Anbeginn</orthForm>
</lexUnit> </synset>


<synset id="vVeraenderung.1617"
lexGroup="Veraenderung" wordClass="verben">
<lexUnit Eigenname="nein" artificial="nein"
id="vVeraenderung.1617.übertragen" orthVar="nein"
sense="1" stilMarkierung="nein">
<orthForm>übertragen</orthForm> </lexUnit>
<lexUnit Eigenname="nein" artificial="nein"
id="vVeraenderung.1617.kopieren" orthVar="nein"
sense="1" stilMarkierung="nein">
<orthForm>kopieren</orthForm> </lexUnit>
<frames> <frame>NN.AN.BL</frame> </frames>
<paraphrases> <paraphrase>von/aus etwas in/auf etwas
schreiben oder zeichnen</paraphrase> </paraphrases>
<examples> <example> <text>Er überträgt die
Zwischensumme in die nächste Spalte.</text>
<frame>NN.AN.BL</frame> </example>
<example> <text>Sie kopierte den Text in das neue
Dokument.</text> <frame>NN.AN.BL</frame>
</example> </examples> </synset>
```

Fig 4: Synset examples

```
<con_rel name="hyperonymy" dir="both" sense="3"
xmlns:xlink="http://www.w3.org/1999/xlink"
xlink:type="extended">
  <locator xlink:type="locator"
xlink:href="verben.Veraenderung.xml#vVeraenderung.16
20" xlink:label="vVeraenderung.1620"/>
  <locator xlink:type="locator"
xlink:href="verben.Veraenderung.xml#vVeraenderung.16
24" xlink:label="vVeraenderung.1624"/>
  <arc xlink:type="arc" xlink:from="vVeraenderung.1624"
xlink:to="vVeraenderung.1620"
xlink:actuate="onRequest" xlink:show="other"/>
 <arc xlink:type="arc" xlink:from="vVeraenderung.1620"
xlink:to="vVeraenderung.1624"
xlink:actuate="onRequest" xlink:show="other"/>
</con_rel>
```

```
<lex_rel name="antonymy" dir="both" sense="1"
xmlns:xlink="http://www.w3.org/1999/xlink"
xlink:type="extended">
  <locator xlink:type="locator"
xlink:href="verben.Veraenderung.xml#vVeraenderung.45.
enden" xlink:label="vVeraenderung.45.enden"/>
  <locator xlink:type="locator"
xlink:href="verben.Veraenderung.xml#vVeraenderung.6.b
eginnen" xlink:label="vVeraenderung.6.beginnen"/>
  <arc xlink:type="arc"
xlink:from="vVeraenderung.6.beginnen"
xlink:to="vVeraenderung.45.enden"
xlink:actuate="onRequest" xlink:show="other"/>
 <arc xlink:type="arc"
xlink:from="vVeraenderung.45.enden"
xlink:to="vVeraenderung.6.beginnen"
xlink:actuate="onRequest" xlink:show="other"/>
</lex_rel>
```

Fig 5: A conceptual and a lexical relation

4. Merging GermaNet with other lexical resources

4.1. Cross-lingual extension with EuroWordNet

Within a European project, the wordnets of several languages, including German, have been integrated into the polylingual architecture of the EuroWordNet database. This has been achieved by linking the language-specific concepts to the Interlingual Index (ILI) of EuroWordNet (Vossen, 1999). The ILI has the following features:

- It is an unordered list of synsets, so-called ILI-records;
- Each ILI-record has a unique identifier, consisting of a categorial marker and a sense ID;
- The ILI-records have basically been derived from the Princeton WordNet; some new ones have evolved from the project;
- The ILI does not account for structural relations between the records. The structural relations are provided by the language-specific wordnets being linked to the ILI.

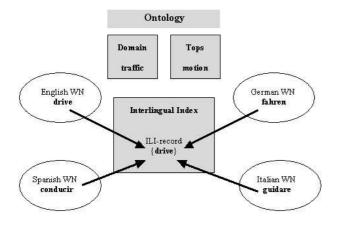An example of the ILI and its satellites is shown in fig. 6

Fig 6: Partial architecture of the EuroWordNet database

From fig. 6, one can derive that there is no direct connection between the wordnets of the various languages. Mappings between language-specific wordnets are mediated by the Interlingual Index.

The following inventory of equivalence relations for connecting synsets of an individual wordnet to the ILI is provided by the EWN specification:

- EQ_SYNONYM
- EQ_NEAR_SYNONYM
- EQ_HAS_HYPERONYM
- EQ_HAS_HYPONYM
- EQ_INVOLVED
- EQ_ROLE
- EQ_IS_CAUSED_BY
- EQ_CAUSES
- EQ_HAS_HOLONYM
- EQ_HAS_MERONYM
- EQ_HAS_SUBEVENT
- EQ_IS_SUBEVENT OF
- EQ_BE_IN STATE
- EQ_IS_STATE_OF

Furthermore, the relations between a wordnet synset and an ILI element are directed. The wordnet synset is the source and the ILI element is the target of this link.

Given these characteristics, we extend the GermaNet relations DTD in the following way:

- Introduce an additional element for this new class of links ("equivalence link")
- Characterize the link as directed
- Define an attribute with the closed set of types which characterize ILI links in the Eurowordnet architecture
- Define two locators for the link, one of which must have an identifier designating a GermaNet synset, the other an identifier designating an ILI element
- Define an arc between these two locators and specify the application semantics of the link during traversal of this arc.

The result of this procedure is shown in fig. 7.

```
<!-- DTD for GermaNet relation files – extended,
interlingual version.-->
....
<!ELEMENT relations (lex_rel | con_rel | eq_rel)+>
…
<!ELEMENT eq_rel (locator+, arc+)>
<!ATTLIST eq_rel name (EQ_SYNONYM|
EQ_NEAR_SYNONYM| EQ_HAS_HYPERONYM|
EQ_HAS_HYPONYM| EQ_INVOLVED| EQ_ROLE|
EQ_IS_CAUSED_BY| EQ_CAUSES|
EQ_HAS_HOLONYM| EQ_HAS_MERONYM|
EQ_HAS_SUBEVENT| EQ_IS_SUBEVENT OF|
EQ_BE_IN STATE| EQ_IS_STATE_OF) #REQUIRED
          dir (one | both) #FIXED 'one'
          xmlns:xlink CDATA #FIXED
'http://www.w3.org/1999/xlink'
          xlink:type (extended) #FIXED 'extended'>
…..
```

Fig. 7: Extended interlingual relations DTD

4.2. Adding form-based lexical descriptions

As one can easily infer from the data model, lexical units are assigned the following pieces of information:

- Their orthographical form is given, and, where applicable, alternative spellings are listed.
- Some of the lexical units are marked stylistically.
- The proper names are marked as such.
- GermaNet includes artificial concepts. The strings which represent these concepts are no proper lexical units. They are therefore marked as artificial. Conceptually, though, this is an exclusion from the set of proper lexical units.

Lexical units are further characterized by their participation in lexical relations such as antonymy and in morphological relations (pertonymy).

Finally, they inherit features which are assigned to synsets. This is in particular the part of speech marker and, in case of verbs, a list of subcategorization frames.

For several natural language processing tasks the information types available in GermaNet are not sufficient. Much more information is needed for tagging, parsing etc. We therefore plan to merge GermaNet with another resource which primarily encodes form-based (phonetic, phonological, morphological, morpho-syntactic) information about units of a German lexicon. This lexicon – IMSLex - will be provided by the IMS Stuttgart (Lezius, Dipper & Fitschen, 2000).

Again, the DTD of GermaNet is a good starting point for the integration of these data. All which has to be done is to extend the content model of the "lexical unit" element and include as subelements the information types which are provided by the other resource. These subelements get an attribute which identifies the source of these bits of information. This attribute serves to keep the resources separate: the information types can be filtered out in order to recover the original GermaNet.

5. Applications

Two example applications which can be based on a standardized data model of wordnets are now discussed: the "Semantic Web" initiative and our current development of a visualization tool which will make the inherent structures of wordnets more explicit.

5.1. The Semantic Web

The "Semantic Web" is an ambitious initiative which aims at enriching the zillions of data objects made accessible via the World Wide Web with semantic information by linking them to a general ontology (cf. The Semantic Web Community Portal).

Efforts have been undertaken by the W3 consortium to provide a common framework for a semantically richer description of resources. These efforts have reached the status of a recommendation, which is close to a standard. The formalism is called "Resource description framework" (RDF, cf. Resource Description Framework Model and Syntax Specification). It is situated within the larger context of XML.

However, the formalism has to be complemented with a vocabulary suitable for describing resources. Thus, ontologies are needed. By definition, an ontology is "a specification of a conceptualization" (Gruber o.J.). WordNet serves well as an interface between natural language and ontologies. Given a standard for the representation of wordnet resources, the various interest groups are able to extend these core ontologies with their specialized vocabularies.

Not surprisingly, conversion of (parts of) WordNet into the Resource description framework already exists (for the schema which describes the resource and the nominal subpart of WordNet, cf. The Semantic Web Community Portal – Library).

This application is restricted to the taxonomical structure of WordNet nouns. It is arguable whether ontologies should be reduced in this way. However, from the XML-representation of GermaNet it is easy to install a converter which translates these data into a format which conforms to the RDF scheme proposed.

In fig. 8 we present two examples from WordNet (cf. The Semantic Web Community Portal – Library) and in fig. 9 two similar examples from GermaNet.

```
<b:Noun
rdf:about="http://www.cogsci.princeton.edu/~wn/concept
#106275359">
    <b:wordForm>beginning</b:wordForm>
    <b:wordForm>origin</b:wordForm>
    <b:wordForm>root</b:wordForm>
    <b:wordForm>source</b:wordForm>
</b:Noun>

<rdf:Description rdf:about="&a;100270320">
    <b:hyponymOf rdf:resource="&a;100270190"/>
</rdf:Description>
<rdf:Description rdf:about="&a;100270440">
    <b:hyponymOf rdf:resource="&a;100270190"/>
</rdf:Description>
```

Fig. 8: RDF notation of a WordNet synset and a WordNet hyponymy relation ("b" stands for http://www.cogsci.princeton.edu/~wn/schema/)

```
<b:Noun rdf:about="GermaNet/concept#nZeit.91">
    <b:wordForm>Anfang</b:wordForm>
    <b:wordForm>Beginn</b:wordForm>
    <b:wordForm>Anbeginn</b:wordForm>
</b:Noun>
<rdf:Description
rdf:about="GermaNet/concept#nZeit.92">
    <b:hyponymOf
rdf:resource="GermaNet/concept#nZeit.91"/>
</rdf:Description>
<rdf:Description
rdf:about="GermaNet/concept#nZeit.93">
    <b:hyponymOf
rdf:resource="GermaNet/concept#nZeit.91"/></rdf:Description>
```

Fig. 9: RDF notation of a GermaNet synset and a GermaNet hyponymy relation (the "b" would now of course point to another schema)

Note that applications which are based on higher order logics can operate on this format whereas the encoding of

the data in a relational database would restrict applications to the lower power of relational database query languages.

5.2. A visualizer for wordnets

The representation of wordnet data is still quite abstract and not very transparent to the human user. The EuroWordNet viewer allows to search and browse the wordnets. However, individual entries are presented without context and are visualized in a text-based format.

We therefore decided to build a viewer which allows both to query and browse GermaNet and which presents the data in a visually appealing and intuitively graspable way.

Potential users of such a visualizing tool are:
-   Lexicographers who want to base their descriptions of lexical units on lexical-semantic fields in addition to their usual semasiological view on the data. Such a view is extremely helpful to derive consistent meaning descriptions. Ide and Véronis (1995) present examples of inconsistent meaning descriptions from English print dictionaries which could have been augmented if the lexicographers were offered a lexical field view.
-   Language teachers and learners. A wordnet which is visually accessible will provide an excellent tool for systematically extending the active vocabulary. For this group it would, however, be nice to provide examples of usage from a large corpus. The glosses and examples encoded in GermaNet constitute the core of such a helpful device. Links to corpus citations still have to be established.
-   Linguists who want to base their systematic work on lexical fields upon reliable lexical data. For instance, research on lexicological aspects in the field of "verba cogitandi" could profit from the subcategorization frames GermaNet provides for verbal lexical units.

Fig.. 10 shows the user interface as it is envisaged. Its design was inspired by Chris Mannings's interface to a Warlpiri dictionary (2001). Our interface will either be directly based on the XML-representation of the data or on a database implementation.
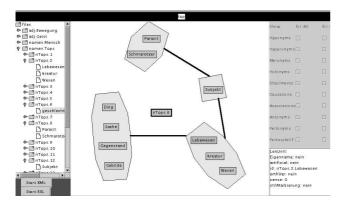

Fig. 10: User Interface to the wordnet visualization tool

The main elements of the interface are:
-   The structure display frame on the left. The hierarchical structure of the (partial) net is being presented in a form familiar to most users from hierarchies of directories and files.
-   The synset viewer in the center presents the synsets of an area chosen in the hierarchical structure. Synsets which are folded present their ID to the user (like the one in the middle of the window). Synsets which are unfolded (the other objects in the window) expand their lexical units.
-   The user can choose a lexical unit to see the information which is provided for this lexical unit. In figure 10 the uppermost lexical unit of the synset in the lower right part of the window is selected. In the lower right frame the information available about the lexical unit *Lebewesen* is displayed.
-   In the upper right frame users can choose which kind of relations they want to highlight. In the current state only hyperonymy relations are possible (displayed by the black arcs).

The visualization tool we present here is work in progress. We will take into account the feedback we get from testing the prototype and will offer a comfortable tool for browsing wordnets very soon.

6. Conclusion

We have presented our recent efforts towards representing and standardizing lexical resources like wordnets in a format which allows for enhanced applicability within mono- and cross-lingual language processing tasks and on the Semantic Web. Aiming at compatibility is crucial in view of merging resources of different types, or extending them with additional information. On the basis of data available which obey the XML standard, various web tools can apply. In summary, with the web adaption of GermaNet, important requirements for ontologies such as wide coverage, task independence and interoperability are met.

7. Acknowledgments

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