

Bringing the “Thesaurus for Economics” on to the Web of Linked Data

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ABSTRACT

Thesauri are possible building blocks of a web of linked data. As DBpedia for large data sets in general, specialized thesauri could be useful as interlinking hubs for professional communities – if they are available on the linked data web. The paper describes the conversion of a large economics thesaurus to RDF/SKOS, using the enhancement mechanisms of SKOS to dispose some non-standard features of this thesaurus. The deployment, using RDFa pages, and the interlinking with other resources, namely a library catalog, and an experimental mapping to DBpedia are presented. For information retrieval support, a SPARQL query facility uses the data for building a thesaurus-backed terminology web service.

Categories and Subject Descriptors

H.3.1 [Content Analysis and Indexing] *Thesauruses*; I.2.4 [Knowledge Representation Formalisms and Methods] *Semantic networks*; H.3.7 [Digital Libraries] *Standards*

Keywords

Thesaurus, SKOS, RDFa, Web Service, REST, Library, Catalog, Economics

1. INTRODUCTION

The “Thesaurus for Economics” (“Standard Thesaurus Wirtschaft“, STW) [6] was developed between 1995 and 1997 within a publicly funded project for the „Unification of economic nomenclature“ in Germany. Its main parts cover economics, business economics and sectors of industry, supplemented by related subject areas, geographical and product descriptors.

Today, the STW is maintained by an editorial board situated at the German National Library of Economics (ZBW) and used by scientific institutions, by documentation centers for economics and business and by GBI-Genios, a provider of business information databases and one of the co-creators of the thesaurus. Its 5,800 descriptors in German and English are presented within a taxonomy of 500 classes to offer an easy navigation along the lines of categories widely accepted in the profession. 17,000 non-descriptors (mainly in German) direct users to the preferred terms. The concepts of the thesaurus are richly interconnected through 15,000 “broader/narrower” and 10,000 “related” links.

The original goal of the current project was to make the STW available on the ZBW web site. The website should offer topical entry points to the library catalog ECONIS¹ and other ZBW databases with a straightforward navigation within the thesaurus and towards the retrieval of books and articles, according to the “follow-your-nose” [13] principle. An automatic generation mechanism which makes it easy to publish new versions of the thesaurus was also a requirement.

We did not want to integrate the generation of the web pages into the thesaurus maintenance application, but aimed for decoupling it through an intermediate text file format. We wanted this format also to be appropriate for publishing the thesaurus as a whole, in order to support subsequent use by others (in ways we would not be able to predict). Encouraging secondary use within the economics community had been a primary objective in the efforts for creating the thesaurus ten years ago. Therefore it will be published² now under a Creative Commons (by-nc-sa) license.

The thesaurus community has developed standards for the construction of mono- and multilingual thesauri, but up to now no standardized serialization format has emerged³. On the other hand, the semantic web community has built the “SKOS - Simple Knowledge Organization System” [10], which is expected to achieve the status of a W3C recommendation in early 2009.

2. RELATED WORK

A structured method to convert thesauri to SKOS has been developed by van Assem et al. [4]. The authors evaluate the applicability of the SKOS meta model to represent the features of existing thesauri. Case studies on The Integrated Public Sector Vocabulary IPSV (UK, government documents), the Common Thesaurus for Audiovisual Archives GTAA (NL, TV/radio programs) and the Medical Subject Headings MeSH (US, biomedical domain) have verified the applicability of methodology and model, but also have identified non-standard features it could not handle.

Later on, other teams (located again at the Vrije Universiteit Amsterdam) concentrated on the area of cultural heritage. Their approach was to use metadata and thesaurus schema mapping, metadata mapping and thesaurus alignment to support retrieval [16]. They applied this process to six individual collections which

¹ <http://www.econis.eu>. The ZBW, as the world’s largest library for economics, holds about 4 million media units.

² <http://zbw.eu/stw>

³ Recently, a development draft for a XML schema for thesauri has been published in the context of BS 8723-5 and the upcoming ISO 25964 (<http://schemas.bs8723.org/XMLSchema.aspx>). The older Zthes schema (<http://zthes.z3950.org>) doesn’t seem to have been widely adopted.

where indexed with six different vocabularies. Thus they could show that unified access to heterogenous collections can be realized using controlled vocabularies and semantic web retrieval tools [11].

These activities were partly inspired by undertakings in the cultural heritage and later in the health information domain in Finland. In a coordinated effort, Finland aims to build a national semantic web infrastructure.⁴ Open and shared ontologies are seen as the main basis for this. The project advocates a more-than-syntactic transformation of existing thesauri to SKOS, refining and enriching the semantic structures.[7] Another focus is on public ontology services, such as the ontology server ONKI SKOS [18], and on applications such as the HealthFinland portal, destined to provide reliable health information to end-users utilizing a broad scale of semantic web techniques [15].

While interoperability and integration into applications was the main concern in these approaches, others concentrated on the accessibility of the data. In an experimental effort, the Library of Congress Subject Headings, one of the largest and most widely used terminologies, were presented as interlinked RDFa/RDF/Json on the semantic web. The authors described in detail the process of conversion from MARC to SKOS and the design and deployment as linked data application [14]. After having abruptly shut off the prototype site, the LC now has announced a re-release of the web service.⁵

In contrast, the Swedish Union Catalogue, held by the National Library of Sweden, exposed its data completely on the web as linked data [9]. Aside from six million bibliographic records, this included also two hundred thousand authority records on authors, titles and subject headings as well as internal and external links. For the subject headings a SKOS representation was used. Since mappings to LCSH had already been created, the Swedish library could easily add links to this information space – “useful for making inferences about relations not present in our system of subject headings from relations present in LCSH” [12].

3. THESAURUS CONVERSION TO SKOS

Following roughly the method given in [4], the conversion of the STW to SKOS was quite straightforward (apart from two areas which required custom extensions which are described below): Main entries build `skos:prefLabels`, “used for” relations went to `skos:altLabels`, and the notes were mapped to `skos:scopeNote` and `skos:editorialNote`. The “broader”, “narrower” and “related” relations directly mapped to the according SKOS properties. The built-in multilingual features of SKOS made it easy to handle the German and English labels connected to the concepts. Other languages, which were used mainly for the original names of geographic units and could not be distinguished automatically, were labeled as “x-other” (according to RFC 4646).

The newly introduced `skos:notation` was a good fit for the notation part of the taxonomy entries. The language-dependent label could have been expressed as `skos:prefLabel`. But this disregards the necessity of presenting the notation as part of a meaningful display label and, even more importantly, as a means for sorting the entries appropriately. For ease of display through standard tools, we decided therefore to transform the language-dependent label to `rdfs:label`, and to build `skos:prefLabel` by a concatenation of `skos:notation` and this label.

⁴ <http://www.seco.tkk.fi/projects/sw20/>

⁵ <http://lsh.info/2008/12/19/uncool-uris/>; <http://id.loc.gov>

⁶ <http://code.google.com/p/skoseditor/>

Technically, the conversion process starts on descriptor and taxonomy files that were, in a custom text format, produced by the thesaurus maintenance application. The files are read by a Perl script and transformed to internal data structures which are necessary for term lookup. Making use of `RDF::Helper` module and the Redland RDF libraries⁷, the SKOS structures are built and dumped to an RDF/XML file.

This file is enriched with some general information about versioning, licensing terms and so on, exploiting the fact that SKOS/RDF allows the intermixture of properties from arbitrary other ontologies (e.g. `dc:publisher`, `owl:versionInfo` or `xhtml:license`). Also, the SKOS vocabulary and the ZBW vocabulary extensions were added. The generated file serves as a base for all further activities.

3.1 SKOS Extensions

For the intended use with a broad range of “knowledge organization systems, such as thesauri, taxonomies, classification schemes and subject heading systems” [10] SKOS provides a very general framework of classes and properties. Knowledge organization systems “in the wild” therefore often use constructs which have no direct counterparts in the standard SKOS language. Therefore, SKOS is designed to make it easy to extend the language constructs by specialization. Hints on how to do this are given in the SKOS documentation.[8] In the case of STW, two extensions have been developed. In our extensions we tried to introduce as few customizations as possible in order to make usage as easy as possible for the unknown user of our data.

3.1.1 Subclassing “`skos:Concept`”

The STW is different from many other thesauri in that it includes a taxonomy of about 500 classes, sometimes subdivided by up to five levels. This thesaurus systematics is not used for indexing, but as an aid for users to find appropriate indexing or search terms (figure 1).

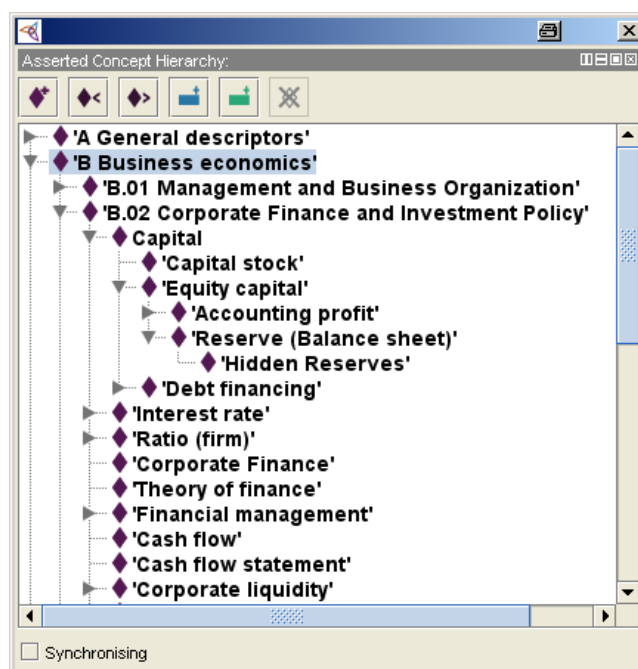


Figure 1. Combined Hierarchy of Taxonomy (in the display recognizable by the alphanumeric notations) and Descriptors, as viewed in SKOEd⁶ Plugin for Protégé

⁷ <http://librdf.org>

Since the STW includes this taxonomy as well as the descriptors themselves, we wanted to have both in one concept scheme. But we still needed some distinguishability, especially to avoid cumbersome phrasing in SPARQL queries. Using `skos:Collection` for the taxonomy was not an option, because this class cannot be nested to express hierarchies. Therefore we choose to subclass `skos:Concept`:

```
zbwext:Descriptor rdfs:subClassOf skos:Concept .
zbwext:Thsys rdfs:subClassOf skos:Concept .
```

One of the advantages of this approach was that we could use the well-defined semantics of `skos:broader/skos:narrower` (and their transitive super-properties) to build and query a common hierarchy of taxonomy and thesaurus, and we also could restrict queries to one of these parts (see example in part 3.2).

3.1.2 Introducing Structured Notes

SKOS already provides a broad range of documentation properties, but cannot cover every special case. The STW uses, besides standard “scope note” with explanations about the intended term usage, also some more formalized notes which link to other descriptors. They offer “use this instead of that” hints – e.g., a note for the descriptor “*Restrictive business practices*” says “*For restrictions on market entry USE Market entry*”. To preserve the semantics of this note (and to offer users an easy-to-click navigation on the generated web pages), we have introduced a new construct:

```
zbwext:useInsteadNote rdfs:subPropertyOf skos:note .
```

Since the range of `skos:note` deliberately was not restricted to literals, we can use a blank node as structured value for this property. The blank node consists of a string with the literal value for the note and a link to the descriptor which should be used instead. For the latter, we did not introduce a special relationship, but made use of the general `rdfs:seeAlso`. The example above can be expressed as

```
<restrictive business practices> zbwext:useInsteadNote
  [ rdf:value "For restrictions on market entry"@en;
    rdfs:seeAlso <market entry> ] .
```

and can be rendered easily to web pages.

In a similar fashion, “see-also” notes could be introduced as another special case of `skos:note` or `skos:scopeNote`.

Nonetheless, applications and readers must be aware of these custom structures. The use of a new sub-property indicates the need for further analysis, and SKOS allows it to define the meaning and structure by the means of `skos:definition` and/or `rdfs:comment`.

3.2 Utilizing SPARQL Queries for Checking Inconsistencies

The transformation to SKOS allowed us to load the thesaurus into a SPARQL server (implemented with Joseki⁸, from the Jena project) and to run all kinds of queries against it. Most useful is the possibility to check the data basis for inconsistencies. A series of standard checks can be executed through the validation service of the Semantic Web Deployment Working Group (SWDWG)⁹. Using the code developed for this service¹⁰ as a blueprint, it was easy to write custom checks to enforce rules for the STW.

⁸ <http://www.joseki.org/>

⁹ <http://www.w3.org/2004/02/skos/validation>

¹⁰ <http://isegserv.itd.rl.ac.uk/cvs-public/~checkout/~skos/drafts/integrity.html?rev=HEAD>

This can be illustrated with an example. Having introduced the distinction between `zbwext:Thsys` and `zbwext:Descriptor` described above, we wanted to verify that a concept of class `zbwext:Descriptor` does not have a concept of class `zbwext:Thsys` as `skos:narrower`. This can be checked by a simple SPARQL query:

```
CONSTRUCT {
  [] a :Error;
    :message 'Descriptor [1] has narrower Thsys [2].';
    :implicated ( ?d ?t );
} WHERE {
  ?d skos:narrower ?t.
  ?d rdf:type zbwext:Descriptor .
  ?t rdf:type zbwext:Thsys }
```

Thus, Thesaurus maintenance can be facilitated by running a series of SPARQL consistency checks on a regular basis to verify the compliance with custom rules.

4. DEPLOYMENT IN RDFa

The deployment of the thesaurus data is meant to serve machines as well as humans. The descriptors and the taxonomy are represented by individual RDFa pages for every concept present in the thesaurus. For human use these pages will be enhanced by a search facility and a taxonomy tree suitable for browsing. Each page is linked to other pages through narrower, broader and related concepts. The URL-rewrite and content negotiation capabilities of the Apache web server are used to do the mapping of requests, e.g. for <http://zbw.eu/stw/descriptor/19664-4> (financial crisis):

1) If `rdf/xml` is requested, a 303 (see other) redirect is performed to the RDFa Distiller¹¹ with the address of the current version English XHTML+RDFa page as a referrer. The user gets the RDF/XML distilled from this page (as suggested in [3]).

2) If `html` or any other format is requested, a 303 (see other) redirect is performed to the current version <http://zbw.eu/stw/versions/8.04/descriptor/19664-4/about>, which is resolved to a language-specific representation by content negotiation (“Options +MultiViews”). The language-specific pages are also addressable directly.

The web pages are produced from the SKOS file by a Perl script, making use of the `HTML::Template` templating system. All triples describing a concept are embedded in the page (though sometimes not visible, e.g. `skos:altLabels` in German on an English page). For a better support in standard tools we embed the super properties of custom properties also. The RDFa syntax makes this very easy as most attributes are defined as whitespace separated lists (eg. “`typeof= ‘skos:Concept zbwext:Descriptor’`”).

The links to other concepts are dual: the clickable href links to a version- and language-specific representation (eg. <http://zbw.eu/stw/versions/8.04/descriptor/19664-4/about.en.html>) in order to make any language choice by a user sticky, while the rdf link to the resource is always designated by the generic URI, (eg. <http://zbw.eu/stw/descriptor/19664-4>).

Version information is embedded in the page by additional triples, with the conceptScheme and the page as a subject. Through an overview page all published versions can be navigated and also downloaded as a RDF/XML zip file. Thus every concept has multiple pages which describe different statuses of its properties, while the identity of the concept remains the same. We regard the stability of the concept URIs as an essential prerequisite for use in

¹¹ <http://www.w3.org/2007/08/pyRdfa/>

indexing and linking to other resources. The “history” of a concept and its changes may be looked up by humans.

Since the primary objective of the project was to produce web pages, embedding additional RDF data into these pages proved an easy way for “semantic enrichment”. The main effort there was to figure out the adequate web server configuration settings.

5. LINKING TO OTHER RESOURCES

Providing links to other resources inside and outside the library was a main design target of the new STW web presentation. The first and most natural aim for this was ECONIS, our own library catalog. The concepts of the thesaurus are imported as an authority file into the catalog and have been used for indexing the books and other media of the library for many years.

5.1 Library catalog

URLs which execute a search in the library system can be easily constructed, with ID values derived from the concept URI or with German or English literal terms as search terms. We decided to use the `skos:prefLabel`, in the user’s favored language, because the search term displayed on the result page is much more informative than an ID.

The links embedded in the page should not only be navigable by human users but also by semantic web crawlers (even though up to now the result pages of the library system lack semantic information). Since the `skos:subject/isSubjectOf` properties ceased to exist, there was no easily fitting property for this purpose. Although it would be questionable to define an `inversePropertyOf`, eg. `dc:subject`, given the large and hardly useful amount of such inverse relations, in our opinion it is clearly desirable to be able to link to collections of resources which are indexed with a given concept. As a standard manner has not been defined yet, we introduced a custom property

```
zbwext:indexedItem rdfs:subPropertyOf rdfs:seeAlso
```

to express the special meaning of the link.

5.2 DBpedia

While we could generate these links unhesitatingly, since we knew in advance that each would hit, this is not true in the open world of other datasets. To connect to the Linked Data Cloud, DBpedia[5] was chosen as the main linking hub. An alignment with DBpedia resources also establishes the chance to offer useful information from Wikipedia to the users of the STW.

The matching was done in a two-step process: First, match all concept labels (preferred and alternate, German and English) against the DBpedia labels and redirects (as lowercased strings). Second, evaluate these matches and build relations where the match can be trusted – if at least one `prefLabel` matches. If both English and German `prefLabels` match, we assume a `skos:exactMatch`, otherwise a `skos:closeMatch`.

raw matches	en	de	total descriptors	5766
prefLabel	3018	1804	sucessful match	3042
altLabel	1081	1822	both prefLabel	1242
total	4099	3626	single prefLabel	1295
			pref- and altLabel	505
			unsuccessful match	2724
			no match at all	1903
			no prefLabel match	552
			prefLabels differ	269

As the results of the raw matches show, the different language emphases of the datasets matter: DBpedia is built around the English version of Wikipedia (and includes only those German con-

cepts to which interlanguage links from English pages have been created), while the STW was developed as a German vocabulary which is enriched with English `altLabels` only step by step.

Another restriction resulted from the unforeseen impact of the adoption of “USED FOR” relations in the STW. In some places, particularly in the products branch, it uses “upward posting” – e.g. “pineapple”, “avocado”, “cola nut” etc. are used for and become `skos:altLabels` for the descriptor “<tropical fruit>”. This is perfectly compliant with ISO 2788 [1] and SKOS. Although not recommended there, it works well in the closed world of a library collection and effectively supports both indexing and retrieval. However, it renders the use of `skos:altLabels` for matching concepts in an open world awkward. In DBpedia, “pineapple”, “avocado” and so on are concepts of their own, and it would be misleading to assume a match with the concept “<tropical fruit>”. This issue could be solved only by intellectual discrimination within the thesaurus maintenance system.

The high amount of unsuccessful matches is not only the result of simple derivations in the compared strings. There is also a (not yet quantified but significant) number of economics concepts which do not exist as entries in DBpedia. Examples of these are “agricultural price”, “annual audit” or “youth unemployment”. While this is disappointing for the task of linking the data sets, it underlines the undeniable importance of technical terminologies as linking hubs for specialized communities.

6. BUILDING A THESAURUS BASED TERMINOLOGY WEB SERVICE

It was recognized long ago that thesaurus resources could be utilized to support retrieval. The paradigm of service orientation in the software universe suggests implementing a terminology service as a web service. A RPC-style, SOAP-based SKOS API for such a service has been defined early on [2]. It has some implementations (e.g. the FACET browser [17]) but appears to have seen no further development. In contrast to these beginnings our approach is based on a REST architecture. It tries to expose meaningful and useful thesaurus-related resources on the web, available through simple HTTP GET requests, using resource names (like “concepts”) rather than verbs (like “getConcepts”).

A beta version of the STW web service¹² has defined three basic resources:

concepts – searches and returns concept URIs for a given search term or query (for ease of handling in an application, eg. for display in a list, accompanied by `skos:prefLabels`). By default, search is restricted to the type of `zbwext:Descriptor` and carried out on `skos:prefLabel` and `skos:altLabel`

narrower – return the `skos:narrower` concept URIs for a given concept URI. (**broadener** and **related** to be defined in the same way to cover the other semantic relations)

labels – returns (by default: all) labels for a given concept (accompanied by the concept URI and its `skos:prefLabel`)

These are the basic building blocks. They could be useful in themselves, for example to enhance a search within a dataset indexed by the concepts of a given concept scheme. If the search term can be mapped to a concept URI by the search application, it can include narrower concept URI via a lookup of the “narrower” service for this concept URI.

However, mostly the user input has to be mapped to concepts, and then resources related to these concepts are demanded. So we

¹² <http://zbw.eu/beta/stw-ws>

define resources which represent combinations of these basic building blocks, e.g.

synonyms – returns synonyms for a given search term or query by chaining **concepts** and **labels**. To give an example: <http://zbw.eu/beta/stw-ws/synonyms?query=free+trade+zone> returns the terms “Export processing zone”, “Foreign trade zone”, “Foreign-trade zone”, and optionally equivalent German terms.

The “packaging” of basic services is not only a matter of convenience, but much more one of performance. Since the services must be well suited for use in search engines for economics resources, it is absolutely critical to get all necessary details required for query expansion in one and only one round-trip.

Currently the web service is already the foundation of the search interface for the thesaurus itself which implements a Google Suggest-like, AJAX-based incremental search. This gives us an opportunity to explore the real-time characteristics of the service and the possibilities and impacts of standard web-caching mechanisms on performance. An integration into a new version of the library's document server retrieval interface based on Lucene could give some feedback about the usefulness of the service when applied to document retrieval and the scalability of the implementation under load.

To explore other kinds of queries, we plan to expose an experimental public SPARQL endpoint based (as the service described above) on a Joseki server.

7. CONCLUSION

Our choice of SKOS and RDF as a publication and exchange format for the “Thesaurus for Economics” has proved successful. We could build on this format for generating a richly interlinked website. The web pages in turn embed the semantic information as RDFa and are connected to the Linked Data Cloud on the web. Further services such as consistency checking and terminological web services could be implemented on the same basis.

A logical future step would be the presentation of links to other terminologies and classifications (eg. the widely used classification of the “Journal of Economic Literature”). Especially if these terminologies and classifications are on the semantic web themselves, new services, such as “translation” services for search queries, are possible. While thesauri provide no strict ontologies, and therefore no basis for automated reasoning, as carefully crafted terminologies they can be highly useful for inter-linking knowledge resources in libraries and beyond.

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