

SNS Environmental Vocabulary – from Terms to Ontology

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Abstract

Semantic Network Service (SNS) is a vocabulary service of the environmental authorities in Germany, established by the Federal Environment Agency in 2003. It combines a thesaurus, a gazetteer, and a chronicle in a hybrid structure with cross-relations. The formal structure has been designed as a Topic Map initially, but now is migrated to OWL in order to build a skeleton of a refined environmental Ontology.

1 Introduction

We focus on the current migration of the SNS vocabulary representation from Topic Maps to OWL. This is a currently ongoing work which may have important consequences for the fields of application. OWL will extend the formal basis of semantic interoperability that Topic Maps already could help to establish, e.g. in the Norwegian government and for several environmental authorities in Germany.

OWL also will pose the challenge to model the “shared and unshared concepts” of the rather hybrid environmental community in a more expressive way than today’s thesauri or gazetteers can do.

2 Ontology of the Environment

Sometimes we wonder whether there are so many shared concepts in the environmental community. Environmental issues cover many disciplines, and the borders are rather undefined. DIRECTIVE 2003/4/EC on public access to environmental information [5] provides us with an "*illustrative and not exhaustive*" list of general concepts while trying to outline what environmental information is about:

... air, atmosphere, water, soil, land, landscape, biological diversity, genetically modified organisms, substances, energy, noise, radiation, waste, radioactive waste, human health and safety, the contamination of the food chain, cultural sites and built structures ...

There is also a wide overlap with the eHealth & Life sciences community.

So much the worse, the diversity of departmental organizations in the administration of the 16 federal states and on the national level in Germany seems to be unthreatened. There is no single ministry covering all these topics, and the specific set of involved departments varies from country to country.

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So many disciplines so many departments so many terminologies, classifications and taxonomies, mostly overlapping and partly inconsistent with one another. With respect to this situation, several "environmental" thesauri and classifications have been manually developed since the early 80s in order to provide a common terminology reference across disciplines - from the point of view of a certain discipline, such a thesaurus can only contain the top level.

2.1 The SNS Topic Map (2001)

SNS combines a German/English environmental *thesaurus* (UmThes®) of some 40,000 terms, a national German *gazetteer*, and a growing collection of *events* that affected the environment. In an R&D project³ started in 2001 [1], we decided to use the Topic Map (ISO/IEC 13250) [9] pattern to integrate the three sub-models, as shown in *Figure 1*.

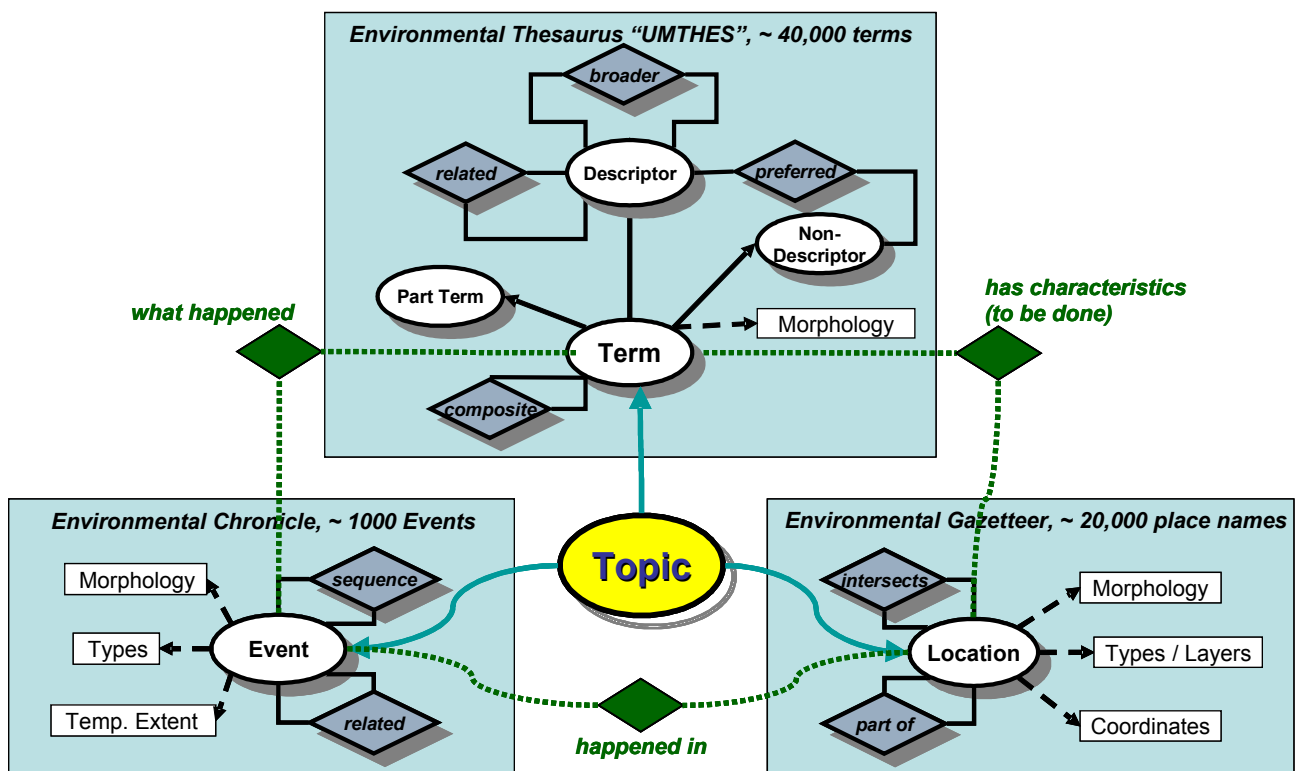


Figure 1 SNS Topic Map Model (2002)

For both Event and Location, the instances of these classes are true individuals, such as a certain accident (Chernobyl) or a certain river (Rhine). A thesaurus should know the terms "Accident" and "River" as Descriptor instances. If it knows individuals ("Chernobyl", "Rhine") as well, they will also be Descriptor instances. Some Thesauri use the Broader/Narrower relation to express instance relationships between such instances. This may sound a little weird, but it is an ANSI Z39.19-2005 recommendation.

³ Research project UFOPLAN-Ref. No. 20111612, promoted by BMU/UBA, Germany

In SNS, we recognise such individuals in Thesaurus sources and store them as Location or Event instances. This is not only done to avoid duplicates, but to allow events and locations to share specific properties (such as spatial intersections, timeSpans, or “happened in” relations) and behaviour specific to the classes.

Topic Maps provide well-defined patterns and the necessary freedom for such a model. Topic Maps have been established in the Norwegian Government [11] and in several other application areas, so one could see this as a proof-of-concept. There are conference tracks at XML Europe or Extreme Markup Languages year by year, and there is a specialized annual Topic Map Research and Application Conference (TMRA) [14].

However, Topic Maps have been derived from SGML in ISO SC34/WG3 in parallel to the W3C Semantic Web Activity. Initially this just happened, but it turned into an inauspicious rivalry. Inauspicious at first for the Topic Map community. While W3C succeeded to integrate DAML and OIL into the OWL development, Topic Map fellows like Garshol [7] or Cregan [4] compared the standards and drafted some OWL representation of Topic Maps, but they finally insisted in some advantages of Topic Maps and in their own independent development. While OWL class definitions and constraints have become ready to use, the forever “upcoming” Topic Map Constraint Language TMCL may be more powerful in some afar future, but still unavailable. While Ontology, RDF and OWL have become kind of “main stream” in the world of semantics, the Topic Map community has been shrinking and the development process slows down. While important application areas such as the *OGC Sensor Web Enablement* or the various flavours of *Semantic Web Services* are preparing to integrate semantics in the formal shape of Ontology and OWL, Topic Maps will need a separate interface or being converted into OWL.

2.2 Thesauri, SKOS, OWL

A thesaurus (ANSI Z39.19) [3] may be seen as a simple ontology, but the classes and properties are restricted and abstract (descriptor, non-descriptor, nodeLabel. Relations broader/narrower, related, use/usedFor – that's it). The terms "waters" and "river" are both instances of the descriptor class with a broader/narrower relation, and not classes (or subclass for river) themselves. Thesauri do not really deal with concepts, but with terms.

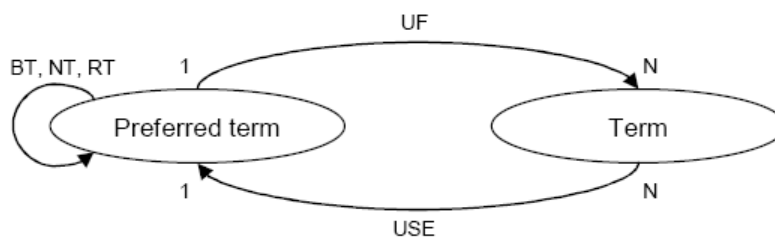


Figure 2 Thesaurus Model [15]

This does not conform to an Ontology in the sense of the OWL Guide [10] (“Design for Use”) “... classes should correspond to naturally occurring sets of things in a domain of discourse, and individuals should correspond to actual entities that can be grouped into these classes.” Descriptors are surely not a “naturally occurring set of things”, but in a strictly formal way Descriptor can be taken as a class with many individuals (=terms).

In 2004, the ECOInformatics Initiative⁴ launched a “Thesaurus and Terminology” area (“*Ecoterm*”) of activity which held an annual meeting since then, hosted by UNEP with programming support by EPA, EEA, JRC and USGS. The Draft Environmental Terminology Agreement by 29 March 2004 outlined the targets with some obligation:

“... in order to facilitate the sharing and reuse of environmental information, ECOinformatics needs some level of semantic interoperability across these terminologies. [...] organizations involved in this agreement will:

- *Implement Web Services connections to their terminology system that allow the EI Web Service to query the terminology in real-time.*
- *Provide full compliance with the Terminology Web Services specification.*
- *The resource will be described on the EI Terminology page with a link to the terminology, if it is publicly available.*
- *Optionally, develop a unique web service of interest to the group, for example, a web service that supports language translation or presentation of chemical structures or other chemical information for a chemical name.”*

Since then, the initiative has been discussing and experimenting Topic Maps, OWL, and SKOS as exchange formats. SNS already supports Web Services since 2003, using XML Topic Maps (XTM) in the body of the responses. Anyway, XTM could not take hold over the W3C Standards. SKOS, the “Simple Knowledge Organisation System”, is part of the W3C Semantic Web Activity “... developing specifications and standards to support the use of knowledge organisation systems (KOS) such as thesauri, classification schemes, subject heading lists, taxonomies, other types of controlled vocabulary, and perhaps also terminologies and glossaries, within the framework of the Semantic Web.” The RDF Vocabulary Specification and the Guide both are 2nd W3C Public Working Drafts (2 November 2005).

From our point of view, there are two objections against using SKOS for SNS:

1. SKOS is exhaustively focussed on thesauri with all their flavours. Extensions necessary for SNS are obviously possible, as everything is RDF, but there is no recommended pattern. There is a page about SKOS Extensions, but the editors state: “*SKOS Extensions is an offshoot of the redevelopment of SKOS Core - it was created to hold some semantic relation property extensions that were initially a part of SKOS Core. Currently the SKOS Extensions Vocabulary has no official home and is maintained informally by Alistair Miles and Dan Brickley. Development is pretty much on hold while we sort out SKOS Core.*”
2. Secondly, we never really understood why SKOS is based on RDF but not on OWL. There is some talk about “*Hybrid SKOS/OWL-DL Ontologies*”, however not very developed.

Maybe it is more appropriate modelling a thesaurus in RDF than in OWL, but this is not true for a complex semantic network only containing a thesaurus as one sub-structure among others. Hybrid formal structures in a single representation appear difficult to handle, especially for the clients who will have to learn about the structure. In case of SNS, if we would introduce a “native” structure for

⁴ <http://ecoinfo.eionet.europa.eu/>

the thesaurus, the next question would be why not to do the same with gazetteer and events and any other branch of semantics in the future.

So we decided to use OWL only throughout the full SNS representation.

Coming back to thesaurus, we were looking for an established pattern to express thesauri in OWL, but we could not find any. Van Assem et al. [14] discuss several examples but do not provide a reference model. The NCI “Thesaurus” [6] is a well known use case, but not a thesaurus in the sense of ANSI Z39.19 as it is “... *strongly ontology-like across several taxonomies ...; containing detailed semantic relationships among genes, diseases, drugs and chemicals, anatomy, organisms, and proteins.*” NCI is an interesting example of Ontology, but not a reference for an ANSI thesaurus in OWL.

2.3 SNS OWL Representation

Finally we decided simply to express the existing SNS structure in OWL directly. There were two representations of this structure: an abstract information model as shown in *Figure 1*, and the XML Topic Map. So there were two possible ways:

1. Convert the SNS Topic Map Representation into OWL,
2. Express the SNS information model in OWL without using the Topic Map pattern.

Garshol [7] and Cregan [4] have provided solutions for representing Topic Maps in OWL. However, we did not really feel like convinced Topic Mappers and considered the drawbacks of carrying along the TM paradigm on our way to OWL. We could not find any convincing arguments to do so. One of the named benefits of XTM is direct support of *n-array* relations. TM *associations* may have more than two *member roles*. RDF/OWL is restricted to triples, so quite a set of expressions is needed for n-array relations. However, SNS does not use n-array relations at all. We never really exhausted the power of Topic Maps, so we can easily express our internal model in both formal structures in parallel. We don't see any need in re-implementing specific Topic Map concepts such as *association*, *member role*, *occurrences* etc. in OWL first.

The next question was: LITE or DL? In our very first draft, we used `<owl:disjointWith>` and enumerations, both of which are DL. We selected multiple classes for Domain and Range of an *ObjectProperty* and found ourselves in OWL Full. Finally, we dropped everything that is not OWL Lite. Our main intention is a simple exchange format to be used within a well known community where implicit semantics are widely shared. We want to collect first experiences with OWL in production, and we want to provide simplicity to users – make it as simple as possible, but not more simple (Albert Einstein). We restricted ourselves to a very “thin” skeleton or “kernel” of the SNS Ontology. The OWL Lite version might be extended to DL later. E.g. the Lite version has no disjoints, but it can be easily extended by only some lines of code.

Finally we ended up with a small model of 18 Classes, 24 *ObjectProperties*, and 24 *DatatypeProperties*, as shown in *Table 1*.

<i>Class</i>	<i>Properties extended</i>
• owl:Thing	
• EventType	<i>None, individuals enumerate event type codes</i>
• LocationType	<i>None, individuals enumerate location type codes</i>
• SNSConcept	altLabel, componentOf, compoundFrom, description, diction, expired, historyNote, lot, modified, modifiedBy, pointer, preferredLabel, qualifier, reference, scopeNote, sortLabel, source, sourceID
• Event	hasEventType, relatedEvent, timeSpan, whatHappened, whereHappened
• RecurringEvent	recFirst, recFixDate, recInterval, recLatest, recNext, recPrevious
• SingleEvent	-
• Location	countryCode, hasLocationType, localeOf, oska, postalCode, spatialIntersection
• FlatLoc	-
• HierarchyLoc	hasTopLoc, parentLoc
• GroupLoc	childLoc
• TopLoc	-
• LeafLoc	-
• Thesaurus	hasTranslation
• HierarchyTerms	hasTopTerm, isBTof, isNTof
• Descriptor	RT, themeOf, usedFor
• NodeLabel	-
• TopTerm	-
• NonDescriptor	use

Table 1 SNS OWL Classes and Properties (current draft, Oct. 2006)

Obviously, this is quite an abstract model, rather close to the thesaurus paradigm and not what we expect from an environmental Ontology. We would have liked to make many of the thesaurus terms classes in a tree (such as Water, Air, Emission, etc.) with specific properties and behaviour. However, we did not have the resources available. We could easily model subclasses of Event and Location following the 31 types listed in *EventType/LocationType*. However: these types do not come along with distinct behaviour, so we left it that abstract.

So far about what we did *not*. Here is what we did:

First we derived *SNSConcept* from owl:thing to define certain general properties needed by SNS, such as different labels, descriptive text and pointers, and administrative assertions. There is only one general object property: *compoundFrom* with inverse *componentOf*. These can be used across the complete vocabulary to handle compound terms, e.g. the “Kyoto Protocol” about greenhouse gas emissions is composed from Location “Kyoto” and Descriptor “Protocol” – we need this for the purposes of text analysis, and some users like it while browsing the terminology.

Now we derived specific classes for each of the (currently three) branches of the SNS vocabulary, Thesaurus, Location, Event.

Thesaurus adheres to ANSI, but it was not so trivial to model *Descriptor* and *NodeLabel* in the hierarchy. A *NodeLabel* is not a *preferred Term* like a *Descriptor*, but it occurs in the hierarchy. In the first version there was no intermediate *HierarchyTerms* class, and we selected *Descriptor* and *NodeLabel* equally as Domain and Range of *isNTof* and *isBTof*. OWL does allow so, but then it is OWL Full. Introducing the intermediate parent appeared to be a working solution.

The *hasTranslation* property adumbrates that we do *not* use symmetric multilinguality [8] in the *Thesaurus*. Symmetric would mean: each concept has a label in each supported language. This is appropriate for Location instances, where “München” and “Munich”, “Rhein” and “Rhine” obviously are different labels of exactly the same object. But it does not work for terms that are not names of individuals. E.g. we have a similar pair of terms in English and in German: “Forest” and “Wood” vs. “Forst” and “Wald”. Though this appears to be symmetric on the first glance, the boarder between the two terms is different in the two languages, so “Wald” translates to “Forest” in most contexts. “Forest Damage” is the only established term in English, while German makes a difference between “Waldschaden” und “Forstschaden”. That’s why we use multiple monolingual instances, connected by *hasTranslation* properties and not multilingual labels of a single instance in the *Thesaurus*.

Event extends a *timeSpan* property. We made several bad experiences with inflating annual anything-of-the-year nominations in the past, so we invented a more sophisticated *RecurringEvent* so each of them can be part of a kind of concatenated list. Apart from that, Event instances can be related to each other as well as to Descriptors and Locations. Event types are:

conference, convention, disaster, guideline, historical, industrialAccident, initiative, institution, law, marineAccident, ofTheYear, publication.

They do not require any distinct behaviour, so there are no distinct classes. Distinct behaviour is only supported for *RecurringEvent* instances which may be of any type.

Location extends some typical properties of spatial objects such as *boundingBox*, *countryCode*, etc. More interesting is *spatialIntersection*, which resembles to *adjacentRegion* and *situatedIn* of the famous vine ontology of the OWL Guide. In SNS, these intersections are systematically computed, based on geographic algorithms (with a little help from the Central Basic Geodata Service for Germany⁵). We also spent some time modelling administrative hierarchies of spatial units such as communities, districts, etc., which is completely different from natural spatial intersections. Location types are:

<i>admin.community</i>	<i>land.mountain</i>	<i>waters.channel</i>
<i>admin.district</i>	<i>land.mountains</i>	<i>waters.lake</i>
<i>admin.nation</i>	<i>land.naturalLandscape</i>	<i>waters.reservoir</i>
<i>admin.state</i>		<i>waters.river</i>
	<i>protected.biosphere</i>	<i>waters.sea</i>
<i>land.catchmentArea</i>	<i>protected.nationalPark</i>	
<i>land.island</i>	<i>protected.naturalPark</i>	
<i>land.landscape</i>	<i>protected.protectedArea</i>	

⁵ http://www.geodatenzentrum.de/geodaten/gdz_rahmen.gdz_div?gdz_spr=eng

They do not require any distinct behaviour, so there are no distinct classes. Distinct behaviour is only supported for *HierarchyLoc* instances which may be of any type though currently only the “admin.xxx” types support this.

Location instances can be *localeOf* Event instances.

2.4 Short Notes about Maintenance

SNS provides a GUI for editing the whole vocabulary from scratch, but this is not the focus, and we do it only for the *Event* instances. Thesaurus and Location are completely obtained from external sources.

The source of *Thesaurus* is UmThes[®], maintained by the Federal Environment Agency⁶ (DE). Updates of UmThes[®] occur intermittent.

The main source of *Location* is the Federal Agency for Cartography and Geodesy⁷ (DE) who provides a Gazetteer Services⁸ (OGC Web Feature Service) “Geographic Names of Germany”. This vocabulary is updated regularly on a yearly basis. The physical form of this source is requesting the OGC Web Feature Service. However, here we need additional computations. The OGC Service specification describes several spatial intersection operators, but only the bounding box operator is implemented. So we use additional algorithms based on a 3x3 km-grid laid across Germany.

After having finalised our new OWL format we will convert any source into this format first, and then run a powerful non-destructive merging machine. This is currently under development. Previous imports have been implemented in a more individual way.

3 A View on Application Areas

The Ontology development is targeted by the application areas.

3.1 Service Orientation

SNS is fully service oriented. At www.semantic-network.de users find an exhaustive documentation of each Web Service operation on this site.

SNS has been developed as kind of “outsourcing” the semantic features of the prior German Environmental Information Network (was: www.gein.de), which now has been re-launched as PortalU (www.portalu.de), in order to provide a shared service to all the associates of this portal [2]. Meanwhile, some applications of the *Spatial Data Infrastructure* are using SNS as well, and we are looking forward to expand number and variety of clients.

⁶ <http://www.umweltbundesamt.de/index-e.htm>

⁷ http://www.bkg.bund.de/nn_858/EN/Home/homepage_node.html_nnn=true

⁸ http://www.geodatenzentrum.de/geodaten/gdz_rahmen.gdz_div?gdz_spr=eng

That's why Web Services are critical. With respect to our clients, we can not afford experimenting at the borderlines of established standards. Even though XML Topic Maps is not that simple, they are just some XML with XSD-Schema, and most clients state that our services are easy to use because we conform to established standards consequently. The services can be fully processed by common platforms like AXIS or .NET without any modification. When we think about using an OWL representation in the body of our service responses as well, we see two unresolved questions:

1. The WSDL mimics are widely established with respect to using XML Schema in the <types> section. We are expecting some trouble when suddenly OWL would appear in this place. If we don't find a solution, we would have to "tunnel" the OWL by a single "xsd:any". In this case the processing of the payload will completely fall outside the processing of the Web Service, which is a really bad practice!
2. Secondly, we are aware of change. The formerly used XML Topic Map structure is abstract in the sense that new topic types do not require schema modifications. Remember each schema modification is a rather ugly event for the clients. Generally in OWL, new types (classes or properties) result in new XML tags and so they modify the schema (in the eyes of the processing engine). The OWL Guide ("Individuals") shows means to use a "weak typing" in the following form:

```
<Region rdf:ID="CentralCoastRegion" />
```

Note that the following is identical in meaning to the example above.

```
<owl:Thing rdf:ID="CentralCoastRegion" />
```

```
<owl:Thing rdf:about="#CentralCoastRegion">  
  <rdf:type rdf:resource="#Region"/>  
</owl:Thing>
```

`rdf:type` is an RDF property that ties an individual to a class of which it is a member.

This might help, but we did not see examples for expressing property instances in this way.

3.2 Searching and Findability

The original intention of SNS was providing a concept-based, automatic indexing of a large corpus, as well as retrieval assistance to be used by the German Environmental Information Network (gein®) which now is continued by the German Environmental Information Portal (PortalU, www.portalu.de).

The process has been derived from the traditional library approach using formalized keywords in the index. SNS has automated both sides of the application of such an index.

- Indexing: automated detection of the significant concepts covered by the document;
- Retrieval: "translation" of any kind of search terms or text passages into searchable concepts.

For such natural language text analyses purposes we make extensive use of the *diction* property of SNSConcept which represents the full set of indicating character strings incl. stemming for each term.

In 2006 we added some specific support for full text search: SNS lists any kind of "similar" terms to be used as full text search terms in order to include many of the different possible notations for the concepts behind a given term.

Findability means also findability of the concept definition and its relations. This is handled in two ways:

- Considering the wide area of terms and place names, the number of homographs is considerable high. SNS uses qualifiers and unique identifiers for each concept in all the services.
- SNS provides refined search methods to find concepts by different criteria.
- The indexing machine of SNS can be used to apply full text documents in the role of a search condition.

3.3 Information and Application Integration

The SNS-based index in PortalU is a simple but powerful instrument of information integration in a portal that represents ca. 100 different information providers. With this index it is easy to harvest the contributions of each provider to a given concept, or combinations of concepts covered by single documents. However, this is only the first step.

SNS unique identifiers are also recommend to be used by reference in data and metadata. This is something we expect to become familiar in the Spatial Data Infrastructure (SDI), namely ISO19115 metadata, and in the Sensor Web.

For the near future we see the establishment of "Semantic Web Services" in combination with a Service-oriented Architecture (SOA), and the upcoming OWL interface of SNS will support these specifications.

4 Outlook

(1) Aside to the here covered general environmental vocabulary, many specialised Ontologies are emerging from classifications, taxonomies, thesauri, etc. Good examples to be at least mentioned here are *Agricultural Ontology Service Project*, FAO⁹, or *Semantic Web for Earth and Environmental Terminology (SWEET)*¹⁰ and many others inside and outside the *Ecoterm* Initiative. The next step will be to link from the SNS vocabulary into these independent, partly overlapping collections by a general crosswalk relation.

(2) Something not yet mentioned in this article is deriving ontology from a given corpus by automatic methods. SNS does not do that so far. SNS integrates several given terminology sources and provides a common representation and interface. However, the manual maintenance of thesauri used to be rather resource-extensive and may not be sustainable. That is why we expect automated methods to become more and more attractive.

⁹ <http://www.fao.org/aims/aos.jsp>

¹⁰ <http://sweet.jpl.nasa.gov/>

(3) The inclination to using Web Services in any kind of information system is undoubtedly growing. This will entail an extended awareness of service choreography and well-defined semantics. SNS is ready to play a reliable role in this scenario.

(4) Finally, automatic indexing will never end to be improvable. We are continuously working on this. Up to now there is one principal restriction which we need to overcome in the near future: till today, SNS only works on each document one by one and ignores all the characteristics common to a certain web site, especially repeated content that is found in every page without being significant for the single page. Examples are: using the organization name in every title; the same keywords for all the pages; hyperlink menus that represent the general topic list of the Website. SNS is used to give a high relevance to title and keywords, but in these cases is misled. More general: SNS should learn to reflect certain aspects of the document context while working on the document.

Resources

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