Sharing Ontology by Web Services:

Implementation of a Semantic Network Service (SNS) in the context of the German Environmental Information Network (gein®)

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Abstract. A thesaurus, a gazetteer and a chronology have been integrated in a consolidated ontology on the basis of the Topic Map pattern. The result has been made accessible to a working information community of 89 environmental authorities in Germany by Web Services technology. A semantically shared ontology can be shared physically in the Web.

1 Introduction

Way back in 1998, the Federal Environmental Agency in Germany launched the German Environmental Information Network [1] (*gein*®, www.gein.de), an R&D project which resulted in the implementation of a first version of an *Internet Information Broker* in 2000. In most aspects, this was what today is called an *agent* in the Semantic Web. *gein*® was a loose coupling of – initially - 50 information providers with about 50,000 Web pages and nine Web-interfaced databases, integrated by the agent (broker) with the help of a - hopefully - shared ontology, common Internet technology, and XML. Thus *gein*® is part of the "database and information system research as they relate to the Semantic Web and more broadly, to gain insight into the Semantic Web technology as it relates to databases and information systems" (http://swdb.semanticweb.org), as it is focused by the current workshop.

gein® successfully applied a common content classification system as a first step to any further content-related integration (or even "harmonization") of the different Internet information sources in its domain. The semantics had been formalized by a Thesaurus, a Gazetteer, and a Chronology. Bases on these, *gein*® was practicing automatic indexing of unstructured documents as well as a distributed query using XML metadata in HTTP requests. With this rather "avantgardistic" approach in 2000, *gein*® proved as the public information portal ("The Portal to German Environmental Information") of the German environmental authorities on the federal and states level anyway.

Following this encouraging experience, a follow-up project named “Semantic Network Service (SNS)” [2] has been launched in 2001 to overcome some restrictions of the initial version of ontology management and automatic indexing by improvements such as:

- Semantic integration of thesaurus, gazetteer, and chronology;
- Resolving of homonym ambiguities by context analysis
- Elaborated criteria for keyword ranking according to their significance in one document.
- Sharing ontology by Web Services
- Accessing semantic methods by Web Services

In this paper, I will concentrate on issues of *Semantics* and *Application*, as these have proved to be the more crucial aspects. The *Infrastructure* (*gein*® and SNS are built on J2EE, with open source as far as possible) sometimes has raised problems in reliability, interoperability, or performance, but these never have been critical for the project. In the following, I will discuss:

- Topic Maps, in their ability to integrate the *gein*® legacy and expose it to the Semantic Web,

- Web Services as an interfacing method that allows to share an ontology not only semantically, but as well physically.

2 Semantic Integration of a Thesaurus, a Gazetteer, and a Chronology in a Topic Map

The SNS project has been started in 2001, and there has been an early decision to use Topic Maps to model the ontology. While there is a – sometimes controversial - discussion about Topic Maps and the Semantic Web [3,45], I recommend considering Topic Maps as a pattern to be applied to Web Ontology. This may include using the Web Ontology Language (OWL) [6] to serialize Topic Maps.

There had been an early RDF discussion [7] in the design phase of *gein*® in 1999 which resulted in the decision not to use RDF as the productive XML format in the network. We implemented a community metadata profile in XML instead, with the option to be converted into RDF later.

In early 2001, we experienced a kind of *déjà vu* discussing the XML Topic Maps (XTM) [8] interchange format. Again, there was a format which was designed on an extremely abstract level, while we were looking for something which was optimized for fast and simple processing. That is why we developed a different XML structure for Topic Maps [9] first, defined in an XML Schema. After XTM became an Annex to ISO13250 as a recommended *interchange* format, we also implemented an XTM interface. From today’s perspective one would consider to implement an OWL interface as well, but this had been out of scope in 2002.

Anyway - none of these formats can embarrass the architecture of SNS, they just add another interchange format. The physical storage structure is encapsulated, following the requirements of a smooth performance. What had attracted us to apply the Topic Map model was not an interchange format, but the semantic pattern of Topic Maps itself, as described in the core ISO 13250 document [10].

Having worked with a thesaurus, a gazetteer, and a chronology, each of them in an individual (XML-) structure, we understood the need for an integrated model. Topic Maps promised a generic pattern to integrate the given diversity without loss.

2.1 Building on Linguistic Inheritance

The *gein*® vocabulary has been developed since 1999 integrating and extending the major semantic sources of the environmental domain in Germany.

The starting point was in the initial requirement to implement a thesaurus-based search with dimensions of *subject*, *location*, and *time*. Following this, *gein*® combined three semantic structures:

1. a thesaurus of currently 39,143 environmental terms (UmThes®),
2. a gazetteer including the intersections between 48,213 geographical objects of all kinds,
3. a chronology – the synopsis of historical and contemporary events that affected the environment.

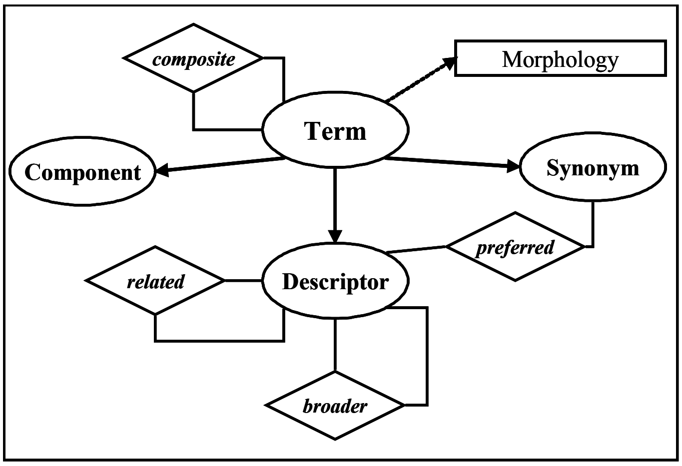

Fig. 1. Thesaurus Model of UmThes®

UmThes® [11] is a full-blown thesaurus supporting all the relations required by ISO 2788/5964 (Broader/Narrower; Synonym; Related; Component), and it contains most of the word morphology, as shown in Fig.1. It is also used by several German-speaking authorities such as the German and Austrian Environmental Data Catalogue, and it is the German source of the GEneral Multilingual Environmental Thesaurus (GEMET) [12,13].

The gein® Gazetteer is based on the GN250 (by Federal Agency for Cartography and Geodesy), but it adds several layers relevant for the environment, and it contains all the spatial intersections as explicit relations in the data, ready-to-use in a rapid query.

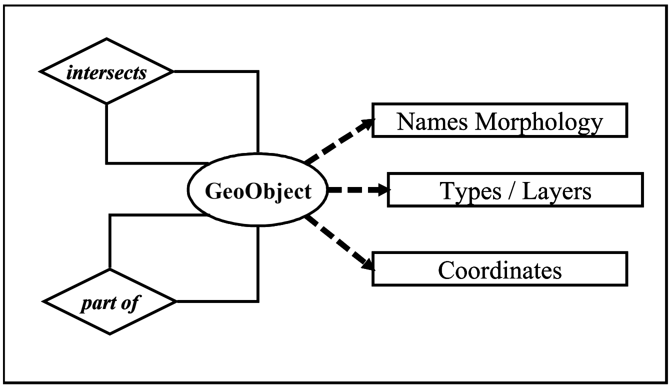

Fig. 2. Gazetteer Model of the "Geo-Thesaurus"

Today there is no established standard about gazetteers as it is for thesauri. There was an early approach of the Alexandria Digital Library in 1999 [14], and now we have the Open GIS Consortium's proposal of a "Gazetteer Service Specification", and the ISO Draft 19112 "Geographic information - Spatial referencing by geographic identifiers" [15]. Fig. 2 shows a generic model which is more or less implemented (or extended) by most of the existing gazetteers.

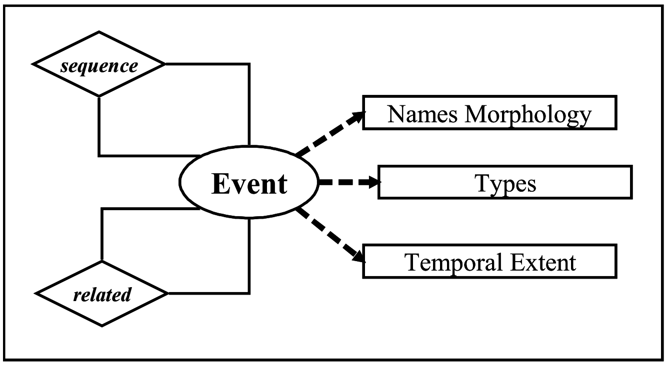

Fig. 3. Chronology Model of gein®

After having harvested a rich ontological legacy for the dimensions *subject* and *location*, we were inspired to find something comparable for the *temporal* aspect. We discovered that there are several symbolic names for events that do not contain any temporal notation, but an implicit reference to a date, such as "before (or after) Christ". While most people in the Christian culture can associate this with year "0", this cannot be postulated globally. Each domain knows its specific major events "by name", and most people cannot tell the exact date that they are talking about when the use phrases like "since the Chernobyl disaster" (1986-04-26). This raised the idea to set up a mapping of symbolic names for events to their dates. The *gein*® Chronology has been started from scratch. Fig. 3 shows the structure.

2.2 Topic Maps

Topic Maps have originated in the neighborhood of SGML, more closely: in the ISO/IEC JTC 1/ SubCommittee (SC) 34 "Information Technology -- Document Description and Processing Languages" [16] which had worked with SGML, DSSSL, HyTime before. Unsurprisingly, the first interchange format has been written in HyTime, two years before an additional XML format (XTM) has been released by TopicMap.org.

But the standardization has not been based on interchange formats ("transfer serializations", which has been stressed by Jim Mason, Chairman of ISO/IEC JTC1/SC34:

“We need to keep clear that the transfer serializations are not the definition of Topic Maps: The standard is the definition. SC34 intends that the supplementary standards will clarify the meaning of Topic Maps without changing their essential nature. (We also recognize that other transfer serializations are possible, outside the standard.)” [17]

Topic Maps have often been described as the "GPS of the Information Space". They can be represented by graphs ("nodes and arcs"), but they are restricted to a more specific pattern of Topics, Associations, and Occurrences. *Topics* have *Occurrences* (in information objects), and there are certain *Associations* between these Topics.

This exactly corresponded to the view of the *gein*® information broker: a Topic may be a thesaurus descriptor or synonym, a geographic object in a gazetteer, an event, (or a person, an organization), whatsoever. Distinct kinds of Topics are defined as Topic Types in a Topic Map instance.

Associations may interconnect Topics in some kind of semantic relation. Distinct kinds of Associations, bound to certain Topic Types as their members, are defined as Association Templates in a Topic Map instance (though this is not sufficiently standardized yet).

An Occurrence may be seen as any kind of existing information about a Topic, but, as Occurrences are “groupings of addressable information objects around topics” [10], this should not be misunderstood to be the general *index* of a “corpora” like *gein*®. In SNS, the document index is separated from the Topic Map. Topics are used as classification properties in document metadata, which rather means: “groupings of topics around addressable information objects” [9].

The current work of SC34 [16] is dedicated to the creation of two related standards:

- ISO 18048: Topic Maps Query Language (TMQL)
- ISO 19756: Topic Maps Constraint Language (TMCL)

It is planned to create a *Standard Application Model* (SAM), a "formal data model for topic maps", flanked by a *Reference Model*, and a *Canonicalization*.

Not only to my opinion, these activities closely relate to the Semantic Web. In particular, couldn't the Web Ontology Language (OWL) [6], which had just advanced to a W3C Candidate Recommendation, function as a "Topic Maps Constraint Language"? I think, definitely yes, although OWL may not satisfy *every* TMCL requirement [18] currently in discussion. This has been explored by Lars Marius Garshol, SC34 member and editor, with the result that "semantic annotations in OWL can be translated directly into a topic map representation of the same information" [5]. While he states anyway that "merging the two technologies does not appear desirable or possible" (ibid.), I see relevant benefits in applying the Topic Map pattern to the modeling of Web ontologies, and in using OWL to serialize Topic Maps and their constraints.

Besides SC34, there is a vivid Topic Map community at OASIS with three technical committees [19] working on "Published Subjects". This work wants to extend the concept of *subjects* as given in the original ISO13250:

"In the most generic sense, a subject is anything whatsoever, regardless of whether it exists or has any other specific characteristics, about which anything whatsoever may be asserted by any means whatsoever." [10]

In this concept, each Topic "reifies" a subject by referencing a "subject indicator".

"Any information resource can be considered a subject indicator simply by being referred to as such by an application, *whether or not that resource was intended by its publisher to be a subject indicator, and whether or not the publisher is aware of (or even cares about) its use as a subject indicator*." [20]

The OASIS TCs are proposing the use of more explicit *published* subjects, *published* subject indicators (PSIs) and *published* subject identifiers (PSIDs). To me this sounds reasonable (and I am personally contributing), but this idea is not necessarily dedicated to solely Topic Maps.

While SC34 still behaves quite reserved about OWL, there is a first draft of expressing Topic Maps in OWL by Bernard Vatant, chair of the TC Published Subjects, providing

"… a reasonable platform for interoperability at a pragmatic level, covering quite a range of moderately complex use cases and applications, without need of any extension of current specifications beyond declaration of a minimal OWL vocabulary" [21].

2.3 Modeling the gein® Ontology in a Topic Map

SNS has defined its own Topic types and Association templates to model the three components of the *gein*® ontology. The *Thesaurus* type and its sub-types reproduce the classical thesaurus structure as defined in ISO 2788/5964. The *Location* type is the abstract parent of all the spatial types such as cities, catchment areas, or national parks. Likewise, the *Event* type is parent of conferences, disasters, and so on.

The given relations (such as broader/narrower terms, or intersection of locations) can be easily typed as Associations. So far, the three different structures can be formally integrated into a single Topic Map without any significant semantic loss or modification.

Beyond this, the three components have been interlinked by two new association types labeled *where*, and *what*. Both of them are using *Event* as the integration point. The *Where*-association links between *Event* and *Location*, pointing out where an event has happened. The What-association links between *Event* and *Descriptor* to describe which subjects have been affected by the event.

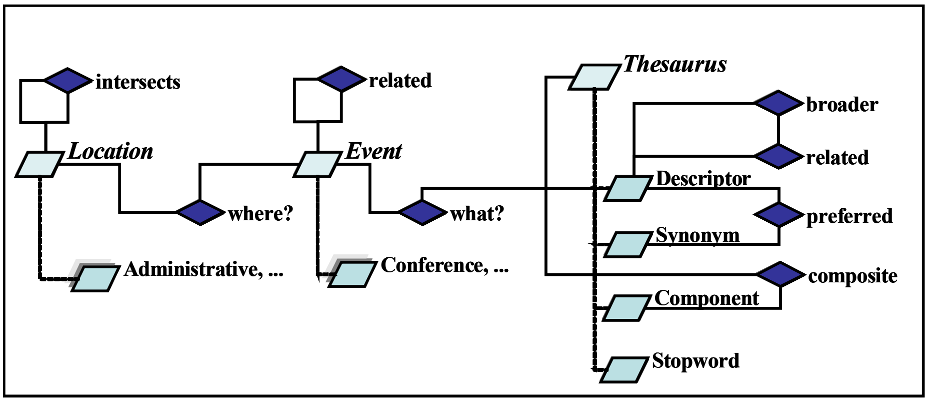

Fig. 4. The SNS Topic Map Typology

This modeling remains implicit, as the Topic Map community still owns no modeling or "constraint" language. There is kind of a "good practice" of describing the types in form of Topics themselves. But there the semantic expressivity of this style is only rudimentary, and there is no well-defined validation as it exists with XML Schema. In 2001, we experimented with using XML Schema to describe our Topic Map model and have the XML serialization validated against it, but this resulted in a rather proprietary solution which finally cannot be recommended. These issues have been discussed more closely in [9].

What I experienced as the most restricting issue is the missing support of extending Topic characteristics in an object-oriented manner. E.g., we need a temporal extent attribute for the Event types, and a bounding box attribute for the Location types. XML Topic Maps allow to (miss?-) use Occurrences to add properties, but you cannot use data types and explicit modeling to do so. This has been solved by OWL.

3 Sharing Ontology by Web Services

The *gein*® Broker has been hosting all the domain ontology since 1999. It has been used for the classification of currently 200,000 static Web pages published by 89 information providers, and in the distributed query to include nine cooperating databases in a distributed query.

There have been several requests by the information providers to be enabled to apply the same ontology and auto-classification methods for their own purposes. Thinking about the effort to prepare a compact module to be distributed for implementation in 89 possibly different technical environments, we preferred to consider a centralized service that can be accessed online by any of them.

gein® looks back to very positive experiences with distributed queries using XML embedded in HTTP requests. We had implemented this communication in the distributed query in 1999, even before the Simple Object Access Protocol (SOAP) had been submitted to the W3C (2000), which initiated the XML Protocol Working Group, and later expanded to the Web Service Activity.

In the recent months, Web Services have been discussed in the context of the Semantic Web quite frequently. In most cases the discussion is about using Web Services to process the Semantic Web, as by Tim Berners-Lee (“A story of program and data as old as computing" [22,23]), or using the Semantic Web for an approved Web Service description, as in Semantic Web Enabled Web Services (SWWS) [24]. Also the W3C Web Service Architecture [25] and the W3C Web Service Choreography [26,27] are recognizing the importance of explicit semantics and ontology to clarify the semantics of services. Similar for UDDI [28], or ebXML [29]. There is an elaborated approach of an "ontology of services" by DAML-S [30].

What we had in mind, was *sharing ontology by Web Services physically*.

3.1 Semantics of SNS Web Services

Based on the application experience in *gein®*, we designed three services [31]:

- Single Topic access by a unique ID (*getPSI*)
- Search for Topics by a single character string (*findTopics*)
- Auto-classification of a natural language document (*autoClassify*)

For "*Single Topic access by a unique ID*", the notation *getPSI* was taken from the Published Subject paradigm already introduced above and is short for: "get Published Subject Indicator (PSI)". We wanted to support Published Subject Identifiers (PSID) for each Topic.

Like in most Web Service applications, we bind this service to the SOAP protocol. However, SOAP does not satisfy the requirement that a PSID must have the form of a single URL, while SOAP needs a more complex protocol (HTTP Post).

Single URLs can have the form of a HTTP Get request, and indeed Web Services can be bound to the HTTP Get protocol. Doing so (additionally to the SOAP binding), a URL like:

http://www.semantic-network.de/.../getPSI?id=uba_thes_24027

will result in a representation of the referenced Topic, in this case the "Technical Instructions on Air Quality Control".

The idea of this service simply is to provide the Topic's characteristics (names, description, etc.) once a client (*agent*) has taken the ID from a reference. A typical use case may be finding this reference in some metadata, and trying to resolve it.

There has been lots of discussion in the committee about the kind of representation of a PSI. Should it be readable for humans or machines? In the Semantic Web, there *must* be a machine readable presentation, so that it may be processed by an agent. Likewise, Web Services are not directly invoked by humans, and an XML format is expected in the response. So this PSI response is definitely machine-readable – (leaving out the argument that XML may be human-readable as well).

A human readable version is also provided by the URL: http://www.semantic-network.de/displayTopic.html?lang=en&tid=uba_thes_24027, but, while this may be called a kind of display service in the Web, it is not a Web Service, as it responds with only semi-structured, display-oriented HTML code.

"*Search for Topics by a single character string*" (*findTopics*) is provided as a classical free text query against the textual properties of Topics. There are several parameters controlling the search tolerance, such as restricting the search to names only or including textual parts of occurrences as well. The basic idea of this service is that the client is looking for Topics that possibly match a given keyword (character string). This is used by *gein*® to assist a human user who wants to proceed from a colloquial term to a Topic. In most cases, more than one Topic is returned, and the list may become quite long when the parameters are set to gain the most search tolerance.

"*Auto-classification of a natural language document*" (*autoClassify*) invokes a linguistic analysis of the passed text. It is the same analysis that *gein*® is using to generate the document index of the corpora automatically, but it may be applied in different cases as well, e.g. using a paragraph of a known document as an initial search condition. In this case, *autoClassify* returns a list of Topics which are significant for the given text paragraph and should be used as search terms.

3.2 Responses are Topic Map Fragments

In the design phase of the service responses we came across the problem that a single Topic with its full characteristics cannot be isolated from the Topic Map it appears in. The reason is Associations. ISO 13250 clearly sees Associations as part of the characteristics of a Topic, but each Association is referring to at least a second Topic. Surely an Association cannot by understood without an understanding of the associated Topic – which has more Associations …

Practice has to find a solution. We have chosen to omit Associations in the results of *findTopics* and *autoClassify* which return lists of Topics, and to leave it to the requester of *getPSI* if he wants Associations to be included in the representation of a single Topic – together with the associated Topics, even recursively. *getPSI* has a parameter named *distance* to control the appearance of associated Topics.

But still, a fragment remains a fragment. Each thinkable subset of a Topic Map is loosing semantics by being isolated from the original context. That is why we decided to let the fragment be explicit, which means adding a notation that expresses the origin, method of filtering (i.e. the request and its parameters), and date of filtering.

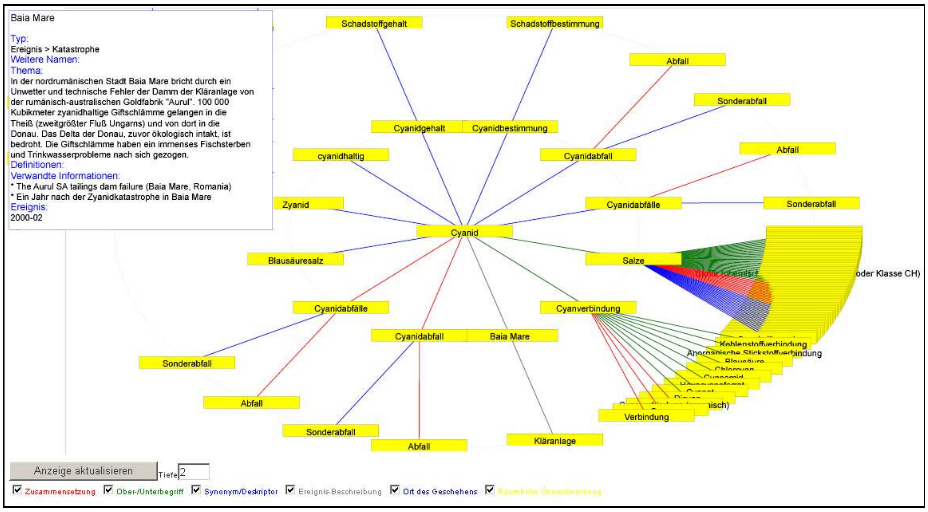

Fig. 5. Interactive SVG graphic displaying a Topic Map fragment

3.3 Formal Web Service Description

In Web Services, the XML structure and syntax of the communication have to be well defined using an XML Schema embedded in the <types> section of a Web Service Description Language [32] document.

More precisely, WSDL does not necessarily require XML Schema, but at least some document type definition written in XML itself (and what would this be else than XML Schema today?). That is why one cannot use a DTD type document structure definition with Web Services (DTD are not written in XML).

As discussed above, XTM provides a well defined XML interchange format for Topic Maps. However, there is no normative XML Schema for XTM. This has been discussed in the public Topic Map mailing lists in February, 2003. In this context there has been a first draft by Max Voskob, which later has been "slightly modified" by Lars Marius Garshol.

SNS uses this version, with one further modification: Neither of the two had declared an explicit XML namespace (xs:targetNamespace) for XTM. This is required so that XML serializations of Topic Maps are able to reference the XTM schema.

Still something was missing: a Web Service provider also needs to describe the requests (*getPSI*, *findTopics*, *autoClassify*) and responses (*topicMapFragment*) in an XML Schema. So we had to provide a SNS.XSD doing so. As *topicMapFragment* includes the <topicMap> defined in XTM, the final structure looks like:

SNS.WSDL embeds SNS.XSD embeds XTM.XSD
(not to mention that XTM imports XLINK).

Given the not too mature state of current implementations of WSDL processors, this structure had its odds and ends to be settled before everything worked on today's major platforms of WSDL processing (Apache Axis and Microsoft dotNet).

4 State of Realization

The SNS R&D project has been finalized end of 2002, with some additional minor enhancements in 2003. The 2003 version of *gein*® replaces the previous semantic methods completely by interfacing SNS Web Services, which will enter the production phase in September.

But SNS has not been intended to be a *gein*®–only service. Its semantic model and functional services are provided for the integration in any kind of information system dealing with environmental issues in Germany, and, as SNS is bi-lingual, internationally.

In the near future there are several integration options, targeted to different users in different application areas, such as

1. UDK (German Catalog of Environmental Data Sources): An administrative agreement [33] of the Federal and *Länder* authorities in Germany has become effective, in which SNS is intended as the common basis of both systems in the next year.
2. gein® Information Providers: the (currently 89) contributing organizations [34] are invited to integrate SNS by Web Services for any kind of information activities. Some of them intend to implement a local version of SNS themselves. Finally, there may be a network of cascading Topic Maps depending on the spatial or thematic focus of an application.
3. GeoMIS.Bund: the “Metainformation-System for geodata of the Federation” of (IMA*GI*) [35], part of the German “national Geo data infrastructure is incorporating SNS to support thesaurus-based search and geographic names.
4. Europe: The eEIONET community discusses “environmental web services e.g. Reportnet, country networks, and metadata, as well as terminology/ontology issues” on a European level [36]. As the relation between GEMET and UmThes® is very close, and as SNS already is working bi-lingual (German/English), it is a candidate to be extended to a European Scope (gazetteer) and to the full multilingual context of currently 19 GEMET languages. This has been proposed in an Expression of Interest [37] within the 6th Framework Program of the European Commission.

5 Conclusions

SNS has successfully integrated the *gein*® thesaurus, gazetteer and chronology legacy into a service-oriented, integrated ontology system that serves a large information community.

Topic Maps have proved as a generic modeling pattern, but there are deficits in a formal modeling language.

Web Services have proved as a working communication protocol in order to access a domain ontology physically.

There are several issues to be solved, among which I regard the most crucial:

- Apply the Web Ontology Language with the Topic Maps pattern.
- Advance the interoperability of the Web Service Description features and XML Schema details to improve rapid implementations on different platforms.

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