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Providing SDI Services in a Cross-Border Scenario: the SDIGER Project Use Case

F.J. Zarazaga-Soria[1], Javier Nogueras-Iso[1], M.Á. Latre[1], A. Rodriguez[2], E. López[2], P. Vivas[3], P.R. Muro-Medrano[1]
[1] Computer Science and Systems Engineering Department, University of Zaragoza. Spain
[2] Instituto Geográfico Nacional, Spain
[3] Centro Nacional de Información Geográfica, Spain

Abstract

SDIGER is a pilot project on the implementation of the Infrastructure for Spatial Information in Europe (INSPIRE), funded by Eurostat, that aims at demonstrating the feasibility and advantages of the solutions for sharing spatial data and services proposed by the INSPIRE position papers, estimating the costs and finding the problems and obstacles of implementing interoperability-based solutions on the basis of real cases. One of the main areas of interest of this project is the cross-border scenario. SDIGER consists in the development of an SDI to support access to geographic information resources concerned with the Water Framework Directive within an inter-administration and cross-border scenario that involves: two countries, France and Spain; and, the two main river basin districts at both sides of the border, the Adour-Garonne and the Ebro. This paper presents details of the problems related with the cross-border scenario found during the development of the project.

Introduction

SDIGER is a pilot project on the implementation of the Infrastructure for Spatial Information in Europe (INSPIRE) (CEC 2004). This project has been funded by the European Commission through the Statistical Office of the European Communities (Eurostat), contract number “2004 742 00004” for the supply of informatics services in the various domains of the Community Statistical Programme. The objectives fixed by Eurostat for this project are three fold. Firstly, it will serve to test and demonstrate the feasibility and advantages of solutions for sharing spatial data and services, observing the principles and standards proposed by the INSPIRE position papers in 2002 and their interoperability-based approach. Secondly, it is useful to acquire experience in implementing interoperable solutions and develop processes able to be reused when INSPIRE is put into operation. And thirdly, it can help to estimate the costs of implementing interoperability-based solutions on the basis of real cases, together with the problems, obstacles which might be encountered during the subsequent large-scale implementation of INSPIRE.

The “call for tender” for this project required the cross-border application to be focused on an environmental subject. The SDIGER project that was then proposed consists in the development of a Spatial Data Infrastructure (SDI) to support access to geographic information resources concerned with the Water Framework Directive (WFD) (OJ 2000) within an inter-administration and cross-border scenario that involves: two

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countries, France and Spain; and, the two main river basin districts at both sides of the border, the Adour-Garonne basin district, managed by the Water Agency for the Adour-Garonne River Basins ("L'Agence de l'Eau Adour-Garonne") and the Ebro river basin district, managed by the Ebro River Basin Authority ("Confederación Hidrográfica del Ebro").

This project has been developed by a consortium consisting of the following entities: IGN France International ("Institut Géographique National France International"), the National Geographic Institute of France ("Institut Géographique National"), the National Centre for Geographic Information of Spain ("Centro Nacional de Información Geográfica"), and the University of Zaragoza (together with experts from the University Jaume I). Additionally, this consortium counts on the help of the following collaboration entities: the National Geographic Institute of Spain ("Instituto Geográfico Nacional"), the Water Agency of Adour-Garonne ("L'Agence de l'Eau Adour-Garonne"), the Ebro River Basin Authority ("Confederación Hidrográfica del Ebro"), the Regional Direction of the Ministry of Environment for the Midi-Pyrenees region, and the French GIS-ECOBAG association.

As it can be observed, these entities (most of them public institutions) are the main providers of the topographic and hydrographic data in the cross-border area. SDIGER is a two-year project that has been structured in the "call for tender" launched by Eurostat in a set of activities orientated to face the problems that may arise in the large-scale implementation of INSPIRE. The activities are presented below and all of them (except for the last one), correspond to the first year of the project:

- Definition of a cross-border scenario. Two application scenario use cases have been defined for this cross-border project. Both of these use-cases are focused on the environmental domain and take into consideration the problematic of at least two adjacent countries and at least two different languages.
- Metadata related activities Three metadata profiles have been developed (a metadata profile for geographical data mining, a generic metadata profile for INSPIRE for assessing and using geographical data, and metadata profile for the Water Framework Directive) with full technical documentation and user guides. An open-source metadata management tool has to be made available. This tool must support the aforementioned metadata profiles.
- Multilingual access portal to data and services. A specific and multilingual portal has been created in order to give access to the geographic information and services produced or served by the institutions being partners or collaborators of the SDIGER consortium. The services accessed through the portal have been configured according to the standards (e.g., Open Geospatial Consortium, ISO TC 211) described in the INSPIRE AST Position Paper.
- Multilingual aspects of the application. French and Spanish are the official languages of the two countries directly involved in the project. Besides offering data and services in these two languages, an English version of the geoportal will be also available to facilitate accessibility to users not familiar with these other two languages. Therefore, multilingual resources like multilingual thesauri and multilingual gazetteers are used to facilitate the creation of metadata and the

development of ergonomic search interfaces for data and service catalogs (Nogueras-Iso et al. 2004).

- Creation of a common object-oriented data model for the data used in the application. A common data model has been created in UML for the harmonized representation of the data involved in the application, mapping later the available data at local repositories into the agreed common model.
- Configuration of the servers for access to the data and services covered by the application according to the ISO TC211 and Open Geospatial Consortium (OGC) standards.
- Internet application. The applications proposed in the application scenario will be implemented by using the elements established in the previous activities.
- Study report for implantation of INSPIRE at the European level. A report based on the previous activities has been written to provide elements to identify problems, solutions and the costs of using configurations commensurate with the European scale of INSPIRE.
- Maintenance for the second year period. The network services and applications must be maintained during the second year of the project; ensuring that average up-time of all servers allows a correct use of the infrastructure.

More details of these activities can be found at (Latre et al. 2005) or in the documents published through the SDIGER project Web site (http://www.sdiger.net). The remains of this paper are focused on the identification of the problems that have been found during the development of this Spatial Data Infrastructure and that are directly or indirectly derived from the cross-border nature of this project.

Cross-Border scenario

The SDIGER project consists in the development of an SDI (see figure 1) to support access to geographic information resources concerned with the WFD within an inter-administration and cross-border scenario that involves: two countries, France and Spain; and, the two main river basin districts at both sides of the border, the Adour-Garonne basin district, managed by the Water Agency for the Adour-Garonne River Basins and the Ebro river basin district, managed by the Ebro River Basin Authority.

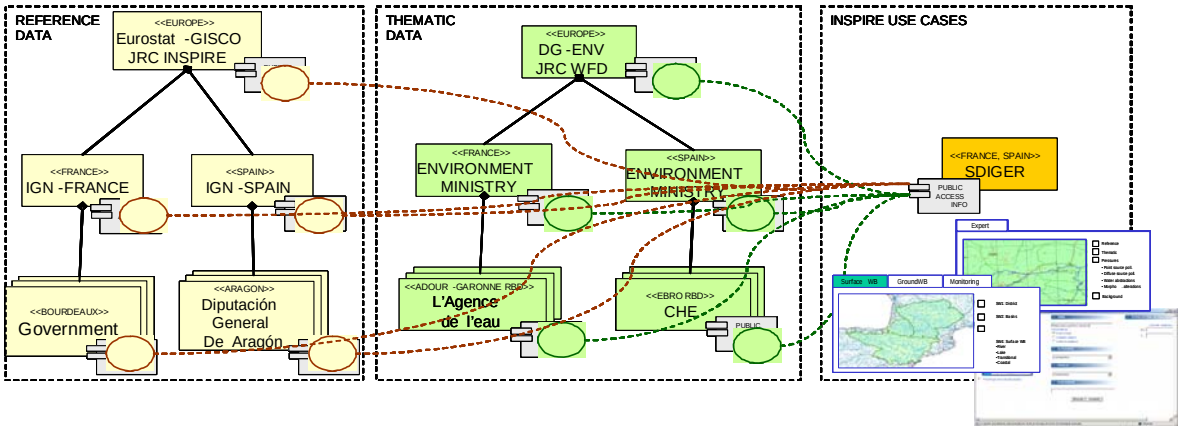

Figure 1. Architecture of the SDIGER SDI

The area covered (see figure 2) by this SDI project is particularly interesting because although most of the Adour and Garonne river basins lay in French territory and Ebro river basin lay in Spanish territory, some stream and river headwaters are located in the other country. This is the case, for instance, of the Garonne river source, which is located in Spain and managed by the Ebro River Basin Authority, and of the Irati river headwaters, an Ebro river tributary which, on the contrary, is located in France and managed by the Water Agency for the Adour-Garonne River Basins. Cross-border information is, thus, of great importance for each of the Basin Authorities in order to assure that the Water Framework Directive requirements are fulfilled in each of the river basin districts. Additionally, this cross-border area includes several protected areas included within Natura 2000, the network of protected areas in the European Union.

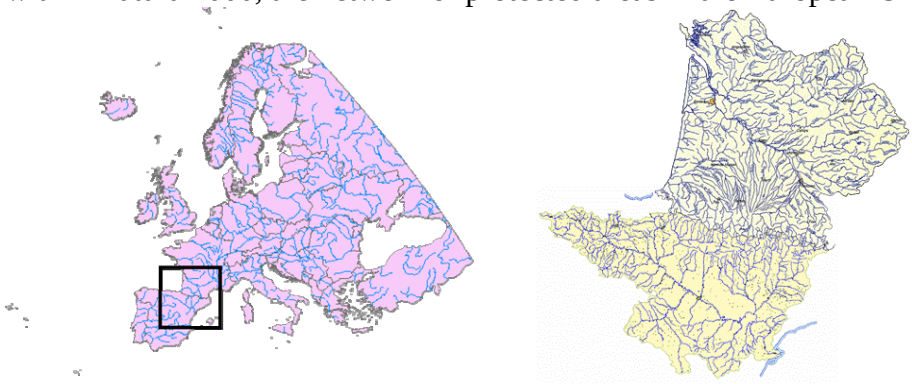

Figure 2.Adour-Garonne and Ebro river basin districts location

Within this scenario, two applications have been developed following the INSPIRE principles and proposed architecture: a first one devoted to perform the reporting activities required by the WFD to the member states (WFD Reporting use case), and a second one oriented to improve the administrative process performed by stakeholders to obtain a water abstraction authorization (Water Abstraction Request use case).

Problems detected

During the development of the project several problems have been found related (directly or indirectly) with the cross-border scenario of the system. Maybe the main aspect that it is necessary to take into account is the different political and administrative organization of the different countries. This different organization is reflected in the administrative processes organization and data models used.

There is also another important source for the problems that is the multilingual heterogeneity. A cross-border scenario not always provides problems related with multilingual aspects. On the other hand, this kind of problems can also be found inside a country (for instance, in Spain there are several regions with more than one official language). In the European Union (EU) there are at this moment twenty official languages. One of the requirements of the system is the multilinguality (Spanish, French and English) of all the services and functionality provided in order to be able to evaluate the problem of providing this kind of services to the whole EU.

These main problems are explained with more detail in the following subsections.

Administrative processes organization. The different legislation and regulations existent in the countries of a cross-border area prevented the design of a seamless and harmonized solution for the problem managed by the applications developed by a project. For instance, the procedures required in Spain and France for the Water Abstraction Request use-case are not equal. Although harmonization usually means interfacing the highest common denominator, it has been necessary to make this use case depend on a series of parameters in order to provide a useful and realistic application. If the system is extended, (i.e., additional River Basin Districts are integrated), the number of parameters may increase

This heterogeneity makes also the problem of defining useful applications in a cross-border scenario very difficult. For instance, the SDIGER project presents a use-case to facilitate the administrative process of the Water Agencies. Nevertheless, to define this use-case was needed to analyze the complex and heterogeneous structure of this administrative process in both River Basin Districts. The results provided us with surprising situations. Let us see two examples:

- Problems related with its specification. For instance, it is not possible to visualize any information about the Water Abstraction Points from one of the countries because this information has restricted access in that country. In the other part of the border, this information is public.
- Existence of security restrictions (e.g. firewalls). It has been necessary to develop and install Web Mapping Service proxies in order to allow the access to services provided by some public institutions that have not their Web Mapping Service available at Internet level.

Data models used. As an extension of the previous type of problems, the participation of different administrations usually implies the necessity of data models harmonization. In the case of the SDIGER project, these harmonization processes have been classified in four: common models for the base data, common models for the metadata, common models for the gazetteer data, and common models for the thesaurus data.

Common models for the base data. In an ideal situation, the data coming from both parts of a border should fit one to each other. However, the real world situation is very different:

- Different conceptual schema languages for the description of the local models.
- Difficulties inherent to the use of native languages for the description of features.
- Most of the data models used at the water agencies in Europe are based on the recommendations provided by the Water Framework Directive GIS guidelines. In those cases the definition of the agreed common models and the conversion of data to the common models are relatively straight. However, when the source data models have not followed these recommendations, the models defined in the different Water Agencies are so heterogeneous that the common model can be only agreed at a very high level. Thus, in those last cases the harmonization processes result to be very hard. Where data has not been created following a predefined model (such as pressure data for the Water Framework Directive), differences among datasets to be harmonized are so big that the harmonization is hard and can only be performed at a very high level.
- In general, the servers used for providing data access, usually Web Feature Servers compliant with OGC (Vretanos 2005), have several structural differences. This used to imply the creation of a software layer that depending on the prerequisites specified by the user performs the appropriate requests in the required format to one or several of the servers.
- The delays in the adjustment of the information served by the data access servers can imply important delays in the development tasks of the applications that use them. For instance, in the SDIGER project initial GML files from the French part did not have relevant information for the application and did not provide information about centroids, the geographic location that should be shown for each water body. In other cases, the lack of some information has disabled the use of some input parameters. For instance, as the units of measure of French data are unknown, it makes no sense the use of the field ‘size’ of the application input form in order to harmonize the units.
- Different Spatial Reference Systems (SRS): Multiple Web Map Servers can only interoperate if they share at least one SRS as a common denominator. Lack of support of specific or common projection systems may prevent the visualization of more than one WMS at a time. The map viewer client integrated within the SDIGER Geoportal acts as a front service that deals with the geometry/image transformation matters. However, if not common SRS is provided by the Map Servers, at very small scales the transformations performed result into a rough overlay of layers originally using different SRS.

Common models for metadata. During many years there has been a wide range of metadata draft standard (regional, national and international) proposals. Since 2003, there is an international geographic metadata standard: ISO 19115 (ISO 2003). Nevertheless, this is a conceptual model for the metadata. The implementation model,

ISO 19139 (ISO 2005), is still a draft. In addition, most of the countries and international organizations are proposing different application profiles. In a cross-border scenario it should be necessary to harmonize different metadata application profiles (usually different subsets of the ISO 19115, with different semantics, and using different controlled vocabulary and thesaurus) over different draft versions of ISO 19139.

Common model for the Gazetteer data. There is no international agreed model for the exchange of data used for the gazetteer. Therefore, the geographic names data stored in the local repositories must be transformed into the agreed common model. Here it is necessary to establish the mapping between the schemas used for the local repositories and the model used for the common model. One of the main problems in this task is to establish the mapping between the typology used for the local database and the typology of features in the common model. For instance, during the development of the project we faced the problem that the French National Geographic Institute provides 74 different types, the Spanish National Geographic Institute provides 50 different types, and the Ebro River Basin Authority provides other 20 different types. These make a set of 144 different types. After studying and harmonizing them, the current gazetteer common data model contains 129 different types.
Other solutions could have been the alignment of different types by using a common thesaurus for feature types. For instance, the two following could have been considered:

- NGA (GNS 2006; NGA 2006). It is a plain list of two levels (8 classes, and 600 types of features) for military use. The advantage is that it has been widely used for the GeoNames server, people has usually taken this as input for different application. The problem is that it does not have hierarchy.
- The ADL Feature Type Thesaurus (Hill et al. 1999; Hill and Zheng 1999). The advantages are that it has a good hierarchy and that it has been used by the ADL Gazetteer. This gazetteer has integrated data of different types and from different sources. The disadvantage may be that it is not interoperated by other services and applications.

Additionally, a good alignment of types based on the use of a common thesaurus should be validated the mapping of geographic locations of features having the same names.

Common model for the thesaurus data. Several multilingual thesauri have been integrated in the SDIGER project with two main aims: firstly, facilitate both the creation of metadata and gazetteer data with appropriate content; and secondly, facilitate the searches performed through the catalog client, and the gazetter client.
For this purpose, it was needed to agree on a common format for the exchange of these thesauri and their upload into a thesaurus service. The agreed common model for thesaurus data has been the SKOS core format. The Simple Knowledge Organization System (SKOS) project (Miles and Brikley 2005) forms part of the W3C Semantic Web Activity and has proposed a model to represent lexical ontologies in RDF. SKOS core is an RDF vocabulary for expressing the basic structure and content of concept schemes as thesauri, classification schemes, subject heading lists, taxonomies, terminologies, glossaries and other types of controlled vocabulary (Alistair et al. 2005). This format has been selected as it is becoming de facto standard for the interchange of thesauri as many thesauri covering different areas are being generated in this format.
Although it seems clear that the adoption of SKOS seems appropriate (justified by its wider use), additional work is required for the adaptation of the thesauri not directly

available in this format. Additionally, it could be necessary to develop special thesaurus whereas there not exists any solution. In the SDIGER project, it has been necessary to build a thesaurus for place keywords in order to be able to manage European territorial units. This thesaurus has been created to facilitate the creation of toponyms and the search interface used for the gazetteer. This thesaurus was obtained from two main sources: the Spanish municipalities were obtained from the National Statistics Institute (Instituto Nacional de Estadística - INE), being the province and autonomous communities compiled manually from the information given by the Spanish Public Administration; and in France, the information of Regions, Departments and Communes was extracted from the National Institute for Statistics and Economic Studies (Institut National de la Statistique et des Études Économiques - INSEE). Both INE and INSEE formats were tabular text. A specific program was needed to transform this into the SKOS Core format.
In addition, the different thesauri used should support the multilingual requirements of the project.

Multilingual adaptation. The multilingual adaptation implies an important problem as concerns configuration management. The software evolution has to manage an additional multy-value variable related with the inclusion of the different languages in a new version of the system. When we are talking about the system, it is necessary to identify the three main areas of the system that are candidates to have problems with the multilingual support: Software itself, Web portal contents, and Documents.

Software. The design of the Software has to include the support for multilingual as one of its key elements. The internationalization of desktop and Web applications is error prone and increase the complexity of the development, implying the use of an infrastructure for internationalization. All the developed software has to be built taken into account the restriction imposed for multilingual support. If any software have not been designed to be able to manage this possibility, it is nearly impossible to provide multilingual support, or the cost of do it could be very high. In this way, it is necessary to manage the use of different encoding of character sets. Some languages (e.g. Polish) require a character set encoding (UTF-8[1]) different from the one commonly used for maybe the most popular languages (ISO8859 for English, French and Spanish).
One additional problem related with the multilingual adaptation is the management of the versions of the system. One of the main problems in the creation and evolution of software systems is the configuration management. In many cases, the multilingual support uses not to be considered in this way. The translation use to be done by different people than the software development. It is necessary to identify clearly the new or modified functionality in order to be able to coordinate the translation processes. Additional tools to identify the elements translated and the ones that it is necessary to translate are welcome.

Web portal contents. Most of the Web portals have a lot of information and service details that are provided to the users. The portal of the SDIGER project provides access to data and services produced and served by the institutions being partner or collaborator of the SDIGER consortium.

[1] UTF8 stands for Unicode Transformation Format. It's one of the 3 possible encodings of UNICODE.

This portal has been structured in four main sections:

- General information about the project. This section provides details about the project (objectives, partners, results …), useful links and any other kind of information that could be interesting for the project audience.
- Generic services. This sections offers access to the three basic services considered: geodata catalog search application, gazetteer application and geographic information visualization application.
- Use case applications. This section provides the applications which implement the two use cases described in the application scenario deliverable.
- Private area. This section provides access (with login and password) to a restricted area where the documents and the deliverables are stored.

Additionally, this portal offers these capabilities with no language restrictions (Spanish, French and English). In order to develop such a multilingual portal, the GUI components (labels, buttons, value lists, …) must be displayed in the language specified by the user. For these requirements, Java internationalization techniques and XML technologies (including XSLT) have been used to dynamically internationalize the software components, load web pages contents stored as XML documents, and apply the appropriate style sheets to display the required portal style and with the appropriate language for text labels.

This model can be extended to other portals taken into account the two main problems found: on the one hand, the difficulties for the development of Web portal infrastructure with capabilities for internationalization (details of the solution implemented in this project have been mentioned above); and on the other hand, the difficulties for the translation of contents of the projects in the different languages. This second problem is very similar to the management of the multilingual evolution of the software. The translation is usually done by people out of the development team. It is necessary to identify clearly the new or modified contents of the portal in order to be able to coordinate the translation processes. Also in this case, additional tools to identify the elements translated and the ones that it is necessary to translate are welcome.

Related with the problem of the portal contents, there are several problems in the multilingual support of the data offered by the Web applications. For instance, catalog services or gazetteer services should be able to provide the means to facilitate the cross-language information retrieval. There are a lot of geographic information resources that are catalogued using only one language, but users that make their queries in one language may be interested in existent resources that have been described in another language. The user is more interested in the resource (map, image or multimedia resource in general) rather than in the metadata describing it. Thus, catalogs must provide users with the mechanisms facilitating the multilingual search without forcing cataloguing organizations to describe their resources in all the possible languages. For that purpose, the following multilingual resources are used in the SDIGER project:

- Multilingual thesauri like GEMET (EEA 2001), UNESCO (UNESCO, 1995), EUROVOC (EC 2006) and AGROVOC (FAO 2006) are used to facilitate the creation of metadata and the development of ergonomic search interfaces for data and service catalogs (Nogueras-Iso et al. 2004).

- Additionally, although the multilingual thesauri facilitate the cross-language information retrieval, it is also important to help the user understand the content of metadata records that may have been written in a language different from the user query language. In that case, it would be desirable to translate on-line the records obtained as a result of the query by means of a machine translation service. For that purpose, SYSTRANLinks from SystranSoft (http://www.systransoft.com) has been selected as the machine translation service used in this project.

Finally, it is necessary to indicate that most of the standards for service specifications do not have into account the problem of internationalization. For instance, through the SDIGER project Web application it is possible to have access to a map viewer that allows the portrayal of the data layers involved in the SDIGER project at different scale levels (European, national and regional). This map viewer is a client application compliant with the Web Mapping Service specification of OGC (Beaujardiere 2004). The main difficulties have been in the internationalization of legends in Web Mapping viewers because the Web Mapping Service standard does not take into account the management of names of layers in different languages.

Documents. A software project does not only consist of software and portal contents, but it also involves all the documents that must be developed and published. Those documents are user manuals, general guidelines, tutorials, and other technical information. In most cases, all these documents should be developed in the different languages of the project. To be able to create these documents, and, specially, to be able to manage their evolution in coordination with the rest of the project, it is necessary to provide a structured and organized process based on a set of procedures and tools adopted from outside or developed within the project. The main objective of these procedures and tools is to make the configuration management system easier in documents, but also in software and contents.

General aspects. To end the comments about the problems related with the multilingual support, it is necessary to remark some aspects that have special impact in all the work that it is necessary to do.
In all the translations the work must be accomplished by translators (people) with enough knowledge in the technical context. If not, the results could have a poor quality and could be incomprehensible.
Finally, the multilingual support increases the work without offering new functionality. Every time that a new language must be incorporated in the project, all the software have to be translated to this new language. In the case of the SDIGER project, the following tasks must be accomplished:

- Internationalization of the metadata edition tool to a new language. This includes the internationalization of the GUI, as well as the translation of the user manuals and profile guidelines
- Translation of the contents of the geoportal into the new language. This includes the translation of the textual contents, the internationalization of the Map Viewer GUI, the internationalization of the Catalog client GUI (both general and thematic), the internationalization of the Gazetteer client GUI, and the internationalization of the Web Application GUI.

General management. The general management of an international and inter-administrative project includes activities like: the project planning and coordination of activities; the preparation of meetings; the creation of the technical framework to facilitate the collaborative work of the different institutions involved in the project (e.g., mailing lists, FTP sites, …); or activities concerned with the diffusion of the project (e.g., participation in workshops, attendance to the meetings of related projects, …)
The participation of different organizations in the development of a project is always a factor that increases the complexity in the coordination in the project. But the case of the SDIGER project is especially problematic because apart from being a trans-institutional project it is also a trans-national project. The project management activity must take into account the different multilingual and multicultural contexts. For instance, it must be noticed that all the participants of the project have been obliged to work in a foreign language (English).
Other of the main problems could be the organization of the physical meeting due to the complexity to agree on the agendas of people working at different institutions and in different countries, and with the problems related with the limitations of the trans-national traveling communications.

Conclusions

SDIGER is a two-year pilot project on the implementation of INSPIRE, funded by Eurostat, that aims to test, estimate the costs and identify the problems of applying the solutions for sharing spatial data and services proposed by the INSPIRE position papers in 2002. One of the main areas of interest of this project is the cross-border scenario. During the development of the project several problems have been found related (directly or indirectly) with the cross-border scenario of the system. Maybe the main issue that has been taken into account is the different political and administrative organization of the different countries. This different organization is reflected in the administrative processes organization and data models used.

There is also another important source for the problems that is the multilingual heterogeneity, which is not always directly related to the participation of two different countries. On the one hand, some cross-border scenarios do not provide special problems related with multilingual aspects (e.g., Austria and Germany). And on the other hand, this kind of problems can also be found within the same country (e.g., in Spain there are several regions with more than one official language). In the European Union there are at this moment twenty official languages.

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References

Alistair, M., B. Matthews and M. Wilson, 2005. SKOS Core: Simple Knowledge organization for the WEB. Proceedings of the International Conference on Dublin Core and Metadata Applications. September 2005. Madrid, Spain.

Beaujardiere, J. (ed), 2004. Web Map Service, v1.3. Open Geospatial Consortium Inc, OGC 04-024.

Commission of the European Communities (CEC), 2004. Proposal for a Directive of the European Parliament and of the Council establishing an infrastructure for spatial information in the Community (INSPIRE). COM(2004) 516 final, 2004/0175 (COD).

European Communities (EC), 2006, EUROVOC Thesaurus, http://europa.eu.int/celex/eurovoc

European Environment Agency (EEA), 2001. GEneral Multilingual Environmental Thesaurus (GEMET), version 2.0. European Topic Centre on Catalogue of Data Sources (ETC/CDS), http://www.mu.niedersachsen.de/cds/.

Food and Agriculture Organization (FAO) of the United Nations, 2006, AGROVOC Thesaurus, http://www.fao.org/agrovoc

Geonet Names Server (GNS), 2006, http://earth-info.nga.mil/gns/html/

Hill, L., J. Frew and Q. Zheng, 1999. Geographic names: the implementation of a gazetteer in a georeferenced digital library. D-Lib Magazine (January 1999), http://www.dlib.org/dlib/january99/hill/01hill.html

Hill, L.L. and Q. Zheng, 1999. Indirect Geospatial Referencing through Place Names in the Digital Library: Alexandria Digital Library Experience with Developing and Implementing Gazetteers. In Knowledge: Creation, Organization and Use. Proceedings of the 62nd Annual Meeting of the American Society for Information Science, Washington, D.C., Oct. 31-Nov. 4, http://www.alexandria.ucsb.edu/~zheng/papers/asis99.pdf

International Organization for Standardization (ISO), 2003. Geographic information - Metadata. ISO 19115:2003.

International Organization for Standardization (ISO), 2005. DTS 19139 Geographic information - Metadata - XML schema implementation. ISO/TC 211 Doc. Nr 1916.

Latre, M.A., F.J. Zarazaga-Soria, J. Nogueras-Iso, R. Béjar and P.R. Muro-Medrano, 2005. SDIGER: A cross-border inter-administration SDI to support WFD information access for Adour-Garonne and Ebro River Basins. Proceedings of the 11th EC GI & GIS Workshop, ESDI Setting the Framework. Alghero, Sardinia (Italia), June 2005

Miles, A. and Brikley, D. (eds), 2005. SKOS Core Vocabulary Specification W3C Editor's Working Draft, http://www.w3.org/TR/2005/WD-swbp-skos-core-spec-20050510/

NGA GeoNet Designations, 2006, http://libraries.mit.edu/gis/data/findingaids/geonet-names/designations.html

Nogueras-Iso, J., F.J. Zarazaga-Soria, J. Lacasta, R. Tolosana and P.R. Muro-Medrano, 2004. Improving multilingual catalog search services by means of multilingual thesaurus disambiguation. In 10th European Commission GI&GIS Workshop, ESDI: The State of the Art, Warsaw, Poland.

Oficial Journal (OJ) of the European Union, 2000. Directive 2000/60/EC of the European Parliament and of the Council of 23 October 2000 establishing a framework for Community action in the field of water policy. The EU Water Framework Directive - integrated river basin management for Europe. L 327, 22/12/2000 pp. 0001-0073 (2000)

UNESCO, 1995. UNESCO Thesaurus: A Structured List of Descriptors for Indexing and Retrieving Literature in the Fields of Education, Science, Social and Human Science, Culture, Communication and Information. United Nations Educational, Scientific and Cultural Organization (UNESCO) Publishing, Paris. http://www.ulcc.ac.uk/unesco/.

Vretanos, P. (ed), 2005. Web Feature Service Implementation Specification, v1.1.0. Open Geospatial Consortium Inc, OGC 04-094.