Search and inventory of GIS interoperability educational resources in the Internet

Meyer A.[1], Gutiérrez J., Béjar R., De Francisco M., Navas M., Rioja R.

Department of Computer Science and System Engineering
University of Zaragoza
María de Luna 3, 50015 Zaragoza (Spain)
[1]ameyer@ebro.cps.unizar.es
http://iaaa.cps.unizar.es

Abstract. Interoperability in Geographic Information Systems is increasingly getting attention within the GIS community. GIS software developers, providers and users are looking to interoperability as a silver bullet in a world of closed and proprietary systems. However, this technological change is not only a matter of software products but a question of sensibility and education of the people that has to implement this change, ranging from the software programmer of the product until the specialized end user. The broad access to the internet and its availability and immediacy has led to the ETeMII project to focus on it as a interesting educational repository. This work illustrates the most relevant issues arisen in an extensive search and inventory of GIS interoperability educational resources in the Internet. Topics such as classifications, keywords, resource types and methodological aspects are revised, whereas search results, resumed and analyzed, provide a view of the state of the art.

1. Introduction

The field of Geographical Information Sciences is subject to fast progressive changes above all as far as the technical development is concerned. A huge amount of spatial data wants to be interchanged, processed and analysed. Unfortunately non-interoperability severely limits the use of the available geographical information material at present. Most spatial data is incompatible and often in vendor-proprietary forms and Geographical Information Systems that can be found in organizations consist of isolated equipment without any possibility to interchange of data or tools with further programs or institutions.

The term interoperability can be understood in a number of ways. From a technical point of view, interoperability in GIS means that software components work with each other to overcome tedious batch conversion tasks, import/export obstacles, and distributed resource access barriers imposed by heterogeneous processing environments and heterogeneous data ([OGC 1996]). Aside from the technical interoperability more and more new demands are also made on the description of the semantics of spatial data. The semantic Interoperability shall make it possible that the significance and the descriptive content

of spatial data becomes understandable for all the different user groups with the objective of facilitating the exchange of information. [Kuhn, 1998], [Harvey, 1999] and [Gahegan, 1999] explain this subject in a more detailed way. Finally an Institutional Interoperability has to be brought about as well that comprises the work flow, consideration of end user dispersion and crossing institutional (national, local, organisational) barriers together with legal aspects (ETeMII, 2001; OGIS Project Technical Committee of the Open GIS Consortium, Inc, 1996 and Bishr et. al, 1999). One of the great challenges Geographical Information Sciences will have to face in the near future is therefore to achieve Interoperability in technical as well as in semantic and institutional issues.

For that reason it is very important to gain a fundamental knowledge of the basic and advanced subjects of what means and how to achieve Interoperability in GIS. In this article it is attempted to elaborate a comprehensive catalogue of educational material covering all the important topics and key words related with "Interoperability in GIS". For this overall objective it was very important to gain general experience of the working process and to develop a method with a focus on documentation which would be applicable in similar projects.

This paper is organized as follows. Section 2 presents the documentary methodology we have pursued. Section 3 concentrates on the most relevant thematic aspects on Interoperability in GIS. The obtained results of the work are shown in section 4. In the latter section it is discussed the availability of the catalogue as a consultation tool in Internet. Finally this work ends with a conclusions and future developments section.

2. Documentary methodology

The search and inventory of educational resources on the Internet regarding Interoperability in GIS concerns a problem which can be solved by means of documentary processing methods. In order to carry out this processing it was made use of a more general documentary model of processing. This model has already proved to be a useful instrument in other projects. The application of the model with regard to the problem one has dealt with led finally to a model that contains the subsequent phases

1. Search. The objective of this phase is to define what to search (interoperability - GI - educational resources), how to search (to establish a strategy of search) and where to search (websites, databases, distribution lists). The strategy of searching is further refined into
    a. Search Engines,
    b. Websites of GIS organisations
    c. Clearinghouses (like virtual library)
    d. Querying on specialised distribution lists
    e. Free navigation

   The results of this phase are a "*Search Strategy*" document.
2. Inventory and brief description. The objective of this phase is to define resource identifications, resource localisations and brief resource descriptions. Every resource should have a unique identification key. It is desired that this key also expresses the location resource. The result of this phase are inventories and precatalogues of metadata.
3. Description. The objective of this phase is to obtain a metadata collection with information about found resources. The data model is based on the Dublin Core metadata standard. The tools used here are computer applications based on the metadata model and information management and search utilities. The result from this phase is a database with catalogued metadata.

4. Classification. The objective of this phase is to obtain a classified metadata collection. The tool being used is the concept map produced in the search phase. The result of this phase are classified and catalogued metadata and thematic indexes.
5. Filtering and quality control. The objective of this phase is to check and improve the quality of the metadata and the resources (quality control). The main tools being used are tools for filtering the resources. The result of this phase is a list of filtering valorisations and an enhanced version of the catalogue.
6. Report Generation. The objective of this phase is to generate project reports and to transfer the products into Word, Excel, HTML and other formats. The tools used here is a set of exporting applications. The result of this phase is a final compilation of discovered resources.

The model presented here is strongly inspired by data processing systems models. This idea is not new [Hilera, 98]. However, one of the key ideas of our processing has been to separate clearly the exactly documentary processing of the data processing.

The data processing system had only to develop very simple tasks, aiming at developing easily the essential documentary processes. The chosen data model keeps closely to the standard of the "Dublin Core". A particularity of this model is that it is more extensive than the standard and enables considering both Dublin Core information and private information for internal use.

For the development of a tool, the programmable database management system Microsoft Access was chosen. The fundamental reason for this decision has been that Access permits a quick development of simple applications. One has taken into account its great ergonomics when carrying out tasks as "drag and drop" showing thereby its high compatibility with other working tools. Furthermore Access has made it possible to generate outputs in diverse formats as well as to take advantage of its own tools to generate reports.

3.   Definition of the thematic background for search and classification

3.1   Key words for "Interoperability in GIS"

In order to make possible a systematic and complete search for educational material within the field of "Interoperability in GIS", a tree of concepts was set up with the support of an intensive literary study which compiled in a clearly arranged and hierarchical way all the important key words. (Figure 1).

A number of institutions and organisations play a significant role in getting "Interoperability in GIS" to work. First of all, there must be mentioned the Open GIS Consortium. Its documents and references have contributed a great deal to the successful compilation of the key words. The most important basis for the setting up of this concept map were the Guide "The OpenGIS® Guide - Introduction to Interoperable Geoprocessing" edited by K. Buehler and L. McKee ([OGC 1996]) and additional publications by [Gardels et al. 1997], [McKee et al. 1999], [Schell et al. 1995], [Goodchild et al 1999] and [Vckovski 1998].
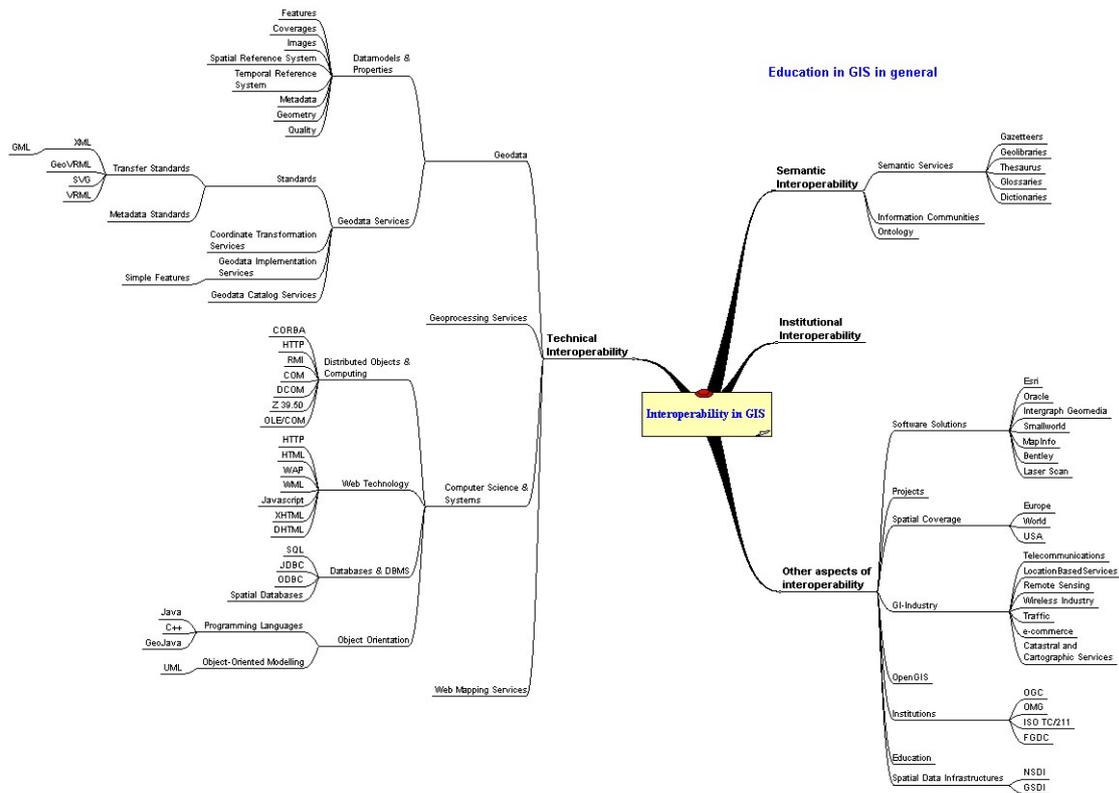
Figure 1: The concept map of key words for "Interoperability in GIS"

The structure of this concept map is made up of a main keyword from which several main groups with still more subdivisions diverge.

The principal keyword is Interoperability in GIS. The four arms that branch off from this principal keyword are "Technical Interoperability", "Semantic Interoperability", "Institutional Interoperability", "Other aspects of Interoperability".

Under the term "Technical Interoperability" all educational materials shall be compiled which are not only supposed to explain the modelling of geodata and their properties, the services and standardisation efforts for a correct access and the transfer and implementation of geodata, but it is also meant to offer an elementary step towards standardizing geoprocessing functions and algorithms.

A further important group of educational materials within the "Technical Interoperability" for the field of "Computer Science and Systems" was collected to cover up essential aspects like "Distributed Object and Computing", "Object Orientation", "Web Technology", and "Databases and DBMS". Webmapping Services form an additional significant group within the field of "Technical Interoperability".

Under the term "Semantic Interoperability" all educational materials are listed which explain the fundamentals and the introductory steps towards a common interpretation of the semantics of data, often

in connection with gazetteers, libraries and thesauri. This section also includes documents which are concerned with the education training about "Information Communities" and the aspects of Ontology.

Educational material with regard to the topic of the "Institutional Interoperability" describes in which way institutional and legal barriers should be overcome to make an exchange of geodata even beyond bounds of public or private bodies possible.

To the definition "Other Aspects of Interoperability" belong all remaining key words which are regarded as essential to bring about a comprehensive qualification in the field "Interoperability in GIS", but which could not be assigned to the other main parts of the concept map:

- Software Solutions: Solutions of software from companies which have the new standards and implementations already integrated into their systems.
- Projects which speed up a new development and can inform about new ideas and standards.
- Institutions: Organisations which are concerned with the "Interoperability in GIS" and the elaboration of standards.
- Spatial Coverage: Comprises educational material which centres especially on the development of the "Interoperability of GIS" in certain regions.
- GI-Industry: Branch - specific documentary and requirements in connection with the "Interoperability in GIS"
- OpenGIS
- Education: Material which describes especially the situation of education in the field of the "Interoperability in GIS"

A further keyword called "GIS in Education" which is not connected as an independent branch with the principal main word "Interoperability in GIS" of the concept map is selected for summarizing some more of the materials as found during the internet search within the scope of the general GIS - Qualification.

Each keyword only occurs once. This applies also to the final links of a branch that cannot be repeated in another group. In consequence this facilitates a subsequent classification, even if some of the keywords in exceptional cases could be assigned to two or more groups of higher importance, dependent, of course, on the found educational document. This fact, however, applies to a great extent only to keywords within the field of technical interoperability. As an example should be mentioned the "Extensible Markup Language" which could be registered in the field of "Transfer Standards" as well as in the field of "Web Technology".

3.2 Resource Types for the "Educational Materials"

For the searching process the thematic key words were linked up by means of searching engines with educational materials in order to influence directly the search for such a material (Tab. 1). Special importance was thereby attached to Tutorials, Courses, Guides, Books and Manuals. But other documentary materials were also accepted during the selective procedure insofar as they are of use for a comprehensive education in the field of the "Interoperability in GIS". To this second group of materials can be counted *Presentation, WhitePaper, Articles, FAQ* and *Glossary*. The thorough search for suitable materials should make it possible on the one hand to find specifications like, for example, the abstract specification and a series of implementation specifications of the OpenGIS Consortium and on the other hand important projects as well which deal with the wide subject area of the "Interoperability in GIS". These fields were provided with names like *Specification, Project Page* and *Project Document*.

Resource Type	Resource Type	Resource Type
Tutorial	Presentation	Specification
Course	White Paper	Project Page
Guide	Article	Project Document
Book	Glossary	
Manual	FAQ	

Table 1: Resource Types of educational material used for the search

3.3 Thematic Classification

Apart from the search purposes, the thematic key words of the concept map "Interoperability in GIS" were also employed to classify the found educational materials to achieve a quicker assignment and tracing of available materials with regard to specific themes of interoperability. During the classification process the total hierarchical path was included in the database under the correspondent field. In this way it is possible to see at once which individual document belongs to which superior subject area.

It depends on the complexity and diversity of the different subjects which are described in a specific educational resource whether it is to be attributed to a superior or inferior hierarchical group. The hierarchical set-up conveys the tree structure of the concept map very clearly (Fig. 1). In case the document describes several final links of an identical key word of higher importance only this one is used for the classification process. Generally can be said therefore that whenever a single document concerns a number of fields out of different subject areas always the next key word of higher importance is used for the classification.

4. The results

The discovered educational materials were analysed according to the coverage of two aspects: the individual subject areas of the "Interoperability in GIS"; and the different types of educational documents. Figure 2 shows in a tabular form the keywords of the concept map and the number of scored hits after the accomplished searching process. For each category of higher importance additional accumulated frequencies are listed which were made up of the sum of the elements of lesser importance. Altogether 289 documents within the field "Interoperability in GIS" and 9 in the field "Education in GIS in general" were acknowledged as suitable and sensible educational resources after having undergone stages of filtering and quality control The results show on the one hand the actual situation of the medium Internet as a source of information in connection with the overall topic "Interoperability in GIS" and on the other the main issues of recent research activities.

As could be expected most of the materials were found in the field "Technical Interoperability". The overriding progress was obviously made in informatics both in theory and practice. The subjects "Semantic Interoperability" and "Other aspects of Interoperability" are still under-represented.

Subjects	Alone	L.4	L.3	L.2	L.1
Interoperability in GIS	20				289
Technical Interoperability	1			199	
Geodata	4		100		
Datamodels & Properties	0	31			
Features	3				
Coverages	1				
Images	3				
Spatial Reference System	5				
Temporal Reference System	0				
Metadata	16				
Geometry	2				
Quality	1				
Geodata Services	0	65			
Standards	0				
Transfer Standards	7				
XML	18				
GML	5				
GeoVRML	1				
SVG	2				
VRML	1				
Metadata Standards	6				
Coordinate Transformation Services	5				
Geodata Implementation Services	3				
Simple Features	4				
Geodata Catalog Services	13				
Geoprocessing Services	4		4		
Computer Science & Systems	1			85	
Distributed Objects & Computing	11	28			
CORBA	12				
HTTP	1				
RMI	0				
COM	2				
DCOM	0				
Z 39.50	2				
OLE/COM	0				
Web Technology	0	17			
HTTP	1				
HTML	3				
WAP	4				
WML	6				
Javascript	2				
XHTML	1				
DHTML	0				
Databases & DBMS	4	18			
SQL	3				
JDBC	5				
ODBC	3				
Spatial Databases	3				
Object Orientation	3	21			
Programming Languages	0				
Java	8				
C++	1				
GeoJava	1				
Object-Oriented Modelling	0				
UML	8				
Web Mapping Services	9			9	

Subjects	Alone	L.4	L.3	L.2	L.1
Semantic Interoperability	7			15	
Semantic Services	0		5		
Gazetteers	4				
Geolibraries	1				
Thesaurus	0				
Glossaries	0				
Dictionaries	0				
Information Communities	1		1		
Ontology	2		2		
Institutional Interoperability	3			3	
Other aspects of interoperability	0			52	
Software Solutions	2	12			
Esri	5				
Oracle	2				
Intergraph Geomedia	1				
Smallworld	0				
MapInfo	2				
Bentley	0				
Laser Scan	0				
Projects	10		10		
Spatial Coverage	0		3		
Europe	3				
World	0				
USA	0				
GI-Industry	2	14			
Telecommunications	0				
LocationBasedServices	6				
Remote Sensing	2				
Wireless Industry	0				
Traffic	1				
e-commerce	3				
Catastral and Cartographic Services	0				
OpenGIS	1		1		
Institutions	0		5		
OGC	2				
OMG	0				
ISO TC/211	2				
FGDC	1				
Education	4		4		
Spatial Data Infrastructures	0		3		
NSDI	2				
GSDI	1				
Education in GIS in general	9				9

Figure 2: Frequency and accumulated frequency of the key words for "Interoperability in GIS"

In addition to the original types of educational materials already adopted for the search further ones were added during the search process and are listed with their final number in Table 2. It is worth mentioning that the resource type *Tutorial* is the most numerous and can usually be downloaded from the Web. It can be observed that the resources are more likely to be self-educated than educational. This can be observed, for example, on the small number of *courses* in comparison with the number of *Tutorials* and similar resources.

Resource Type	Count	Resource Type	Count
Tutorial	44	White Paper	7
Specifications	37	Contribution Paper	7
Presentation	36	Report	7
Article	35	Project Document	6
Linkpage	33	Manual	5
Book	22	Glossary	3
Examples	17	Beginner Page	3
Project Page	14	FAQ	1
Guide	10	Dissertation	1
Course	9	Code Library	1

Table 2: Frequency of the different resource types

5. Catalogue as tool in Internet

The search and inventory of resources in Internet gave rise to achieve more than a simple report or listing of resources. Initially two possible orientations were considered. The first one consisted in the generation of a list or report with the found resources. The other one meant to adopt procedures leading to a more thorough organization of the information that had been found. This would mean the possibility of a better use and exploitation of the obtained information.

Starting from this second idea, a processing of the gathered information was carried out in line with the criteria and standards of documentary processing. In this way the necessity was considered to organize the resources in a Catalogue of Resources. For that purpose, a database was generated which is compatible with the standard of "Dublin Core" the data of which has been classified in accordance with the most relevant concepts of the field "Interoperability in GIS". The result of adopting this perspective has been the obtainment of a tool which allows the convenient exploitation of the obtained information.

This new Catalogue of Resources will soon be available in Internet and means that as a result a new resource of Interoperability in GIS will be incorporated in addition to the already existing ones in the net.

6. Conclusions

The experience gained in the course of this work has made it possible to acquire and to guarantee the "know how" by means of which it was possible to carry out these types of documentary tasks. This knowledge will be of great utility for the development of future projects. In this way, independent of the actual problem, a reliable methodology for documentary search on the Internet can be applied. On the other hand a classifying hierarchical system (Concept map) of the field "Interoperability in GIS" is now available. At the same time one has remarkably increased the knowledge about the available resources in Internet of this topic which is reflected in a catalogue of detailed information. Another significant result is

the availability of this catalogue of resources as a new contribution in Internet towards "Interoperability of Geographic Information Sciences and Systems".

References

Bishr Y. A., Pundt H., Kuhn W. , Radwan M., 1999. "Probing the concept of information communities – a first step toward semantic interoperability. In: Interoperating geographic information systems". Eds: M. Goodchild, M. Egenhofer, R. Fegeas & C. Kottman. Kluwer Academic Publishers. Bosten, Dordrecht, London, p. 55-69.

Burrough P. A., 1997. "GSDI and ESDI –Views on Interoperability and Spatial Data Infrastructures in Europe". Utrecht, The Netherlands. http://www.gsdi.org/docs/parma.html

ETeMII, 2001 ."Reference Data White Paper (v1.0)". http://www.ec-gis.org/etemii/forum-rd/ETeMII_Reference_Data_White.pdf

Gahegan M. N., 1999. "Characterizing the semantic content of geographic data, models and systems. In: Interoperating geographic information systems. Eds: M. Goodchild, M. Egenhofer, R. Fegeas & C. Kottman. Kluwer Academic Publishers. Bosten, Dordrecht, London, p.71-83.

Gardels K. "The Open GIS Approach to Distributed Geodata and Geoprocessing". http://www.regis.berkeley.edu/gardels/envmodel.html

Goodchild, M., M. Egenhofer, R. Fegeas and C. Kottman (Eds.), 1999. "Interoperating geographic information systems". Kluwer Academic Publishers. Boston, Dordrecht, London.

Harvey F., 1999. "Designing for interoperability: Overcoming semantic differences. In: Interoperating geographic information systems". Eds: M. Goodchild, M. Egenhofer, R. Fegeas & C. Kottman. Kluwer Academic Publishers. Bosten, Dordrecht, London, p. 85-97.

Hilera J. R., Martínez J.M., 1998. "Ingeniería Documental Asistida por Computador (C.A.D.E.)". VI Jornadas Españolas de Documentación (Valencia, 29, 30 y 31 octubre 1998), FESABID.

Kuhn, 1998. "Wenn sich GIS untereinander nicht verstehen: Fallstudien zur Semantik von Geoinformation". http://ifgi.uni-muenster.de/english/3_projects/sip/presentations/gis_semantik_1.htm

McKee, L. and C. Kottman ,1999. "Inside the OpenGIS Specification", http://www.opengis.org/info/gisworld/PERSArticle9910LMCK2.htm

OGC, 1996. "The OpenGIS® Guide - Introduction to Interoperable Geoprocessing. Part 1 of the Open Geodata Interoperability Specification (OGIS)". OGIS Project Technical Committee of the Open GIS Consortium, Inc, 1996. Eds.: Buehler, K. and L. McKee. Wayland, Massachusetts, USA. http://www.opengis.org/techno/guide/guide.doc

Schell, D., McKee L., Buehler, K., 1995. "Geodata Interoperability – A key NII Requirement". White Paper submitted to the NII 2000 Steering Committee of the Computer Science and Telecommunications Board of the Research Council, April 27, 1995. http://www.opengis.org/techno/articles/nii2000.htm

Vckovski A., 1998. "Interoperable and distributed processing in GIS". Taylor and Francis LTD., London. 230 p.