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On the Problem of Finding the Geographic Data We Are Looking For

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Introduction

Spatial data is one of the most critical elements underpinning decision making for many disciplines at the local, regional, and global levels. Consequently, the number and diversity of potential users of this kind of information have increased significantly over the last few years. Nowadays not only geographers, cartographers, and GIS scientists are interested in exploiting spatial data, but also governmental agencies, policy makers, ecologically oriented scientist, national defence agencies and even the general public are getting quickly into this new field. This has given rise to new demands for improved infrastructures that support discovery, access, and use of this information in the decision-making process. These infrastructures are given the name of "Spatial Data Infrastructures" [1].

Particularly, the term "Spatial Data Infrastructure" –SDI for short- is generally used to denote all those elements (people, policies, standards, services, networks, datasets, etc) necessary for the effective collection, management, discovery, access, delivery and utilisation of spatial data in a specific community. Among the varied factors that determine the adequacy of a SDI, it is widely acknowledged that the existence of adequate search services is of top importance.

These services will be the elements that provide end users with the appropriate functionality for finding the information they are looking for. The definition of these services is not an easy labour. The first step consists in the characterization of the target audience. Many aspects must be taken into account: SDI objectives, SDI application domain (tourism, environment, agriculture, risk management…), end-users level of experience inside the GI world (public in general, low-level experts …), etc. The final objective is to provide each user with the specific search services that better fit their needs.

In many cases, search-services are based on the direct association of metadata attributes and the values we want on them. The most popular of these services is the one provided by the National Geospatial Data Clearinghouse [2]. It offers an interface with some of the most typical search metadata elements and enables users to specify values for those elements. This kind of search services forces users to have an important background in metadata fields and values. Although the top priority audience for NGDC interfaces is the community of GIS specialists, great efforts are being spent on supporting broader user audiences, such as scientific researchers, educators, students, commercial data providers and even the general public.

Another big problem in search services is to present the appropriate information for describing the datasets found with enough detail to be useful for end-users. In some cases the title of the dataset will be enough but generally the users will need more varied information in order to assess the relevance of the item.

In this paper, after setting up some basic concepts, we introduce the reader to a short assessment of the suitability of typical search services accessible through the web, taking as a main point of reference the Data Clearinghouse search facilities offered by the NGDC. We are especially interested in showing that these search services do not stand out for providing the usual functionalities needed by non-technical users. Consequently, we continue by describing a higher level approximation for the creation of search services based on two primary points: an increase in the level of abstraction of the interfaces and a special focus on client-side component-based development as a means of speeding up the development cycles.

Search Services: Basics

One of the main components of a SDI is the set of geodata search services. Within the geospatial community these services, together with some sort of access capabilities, are known under different names, as "Catalog Services" (OpenGIS Consortium) [3], "Spatial Data Directory" (Australian Spatial Data Infrastructure) [4] or "Clearinghouse" (U.S. FGDC) [2], but all aim at the same goal: discovering geospatial data in the best and most effective possible way.

The consideration of some basic search-related concepts, some of them drawn from the field of digital libraries [5], is of great relevance, as one of the main problems a typical user encounters is the tight-linkage between user interfaces and low level details. There is also an interest to analyse some well-known search services in order to assess their adaptability to the needs of the users.

Basic Search Services Concepts

In order to evaluate existing implementations of search services it is essential to make some prior basic considerations. First of all, it is of vital importance to identify the *user audiences*, i.e., the individuals who are going to use the system. In this respect, the *usability* problem is of the highest relevance. In second place, a *reference framework* aimed at guiding developers in designing the system has to be devised.

Helping users find information is among the core services provided by any information system and a SDI is not an exception to this general rule. Nonetheless, there can be a great variety of user types. In the case of geodata search services, the potential users can fall into very different groups in terms of levels of expertise and objectives. Among others:

- *GIS specialists*: Characterized by a high degree of expertise and familiarity with low-level details as metadata standards nuances and other technical aspects. This group could be interested in almost any aspect of available information. Flexibility is required.
- *Members of government agencies*: This group is not as well familiarized with metadata standards and low level details as GIS specialists are, but does not lack some sort of broad knowledge of the GIS field. In addition, this group is interested in more concrete information than GIS specialists.
- *Scientific researches*: These typically seek very concrete information that will complement their own research data. Their professional backgrounds let them make use of complex interfaces but nonetheless are not interested in dealing with low levels details.
- *General public*: This group is growing in number day by day. They do not have any knowledge about metadata standards or other low level details. Search services have to be provided through simple and intuitive interfaces and the information they require as an output has to be concrete and meaningful. This group is the one we are more interested in.

Nonetheless, no matter the users group, the search services have to be usable. Usability, i.e., the extent to which a user can take advantage of a series of services in an easy and effective manner, is a property of the entire system. That is why it is so important to have a clear conceptual picture of the system as a whole. The different aspects to deal with in order to devise an adequate search service are shown in Fig 1:

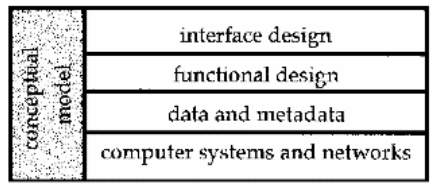

Fig. 1. Layers of design of a search service

It can be observed that the user interface design is at the upper level. A great effort has to be undertaken to make this interface adequate enough for the target users. This is so because the user interface is the means a system uses to provide certain functionalities to the outer world. Nonetheless, if these functionalities do not match the needs of the users or are badly thought out, no matter the user interface, our target audiences will be disappointed. Other levels reflected in Fig 1 are those comprised by the *dada and metadata* and the *computer system.* It is important to stress here that these two deep levels are invisible to the user. Finally, there must be a global model which binds the other levels together. This is the *conceptual model*. It is difficult to underestimate the importance of this model, given the fact that it describes the manner in which the system is to be used**.**

The conceptual model establishes the metaphor and paradigm used to search for specific information. There are many possibilities. *Direct searching* is just one of the possible strategies that people use to find data. *Browsing* is another popular and effective method for discovering the unexpected. In addition, users can be interested in finding everything on a specific topic, using what is known as a *comprehensive search*, or they may know in advance the specific item they are interested in, having to use a *known-item search* in that case. Sometimes, the users just want some *overview information of a topic*, other times they require specific items that may be found in many sources of information (*searches for facts)* and in some cases even want to navigate through related items.

According to the GSDI, the reference framework for a GIS system, which reflects the general aspects of the conceptual model, is the one presented in the Fig 2.

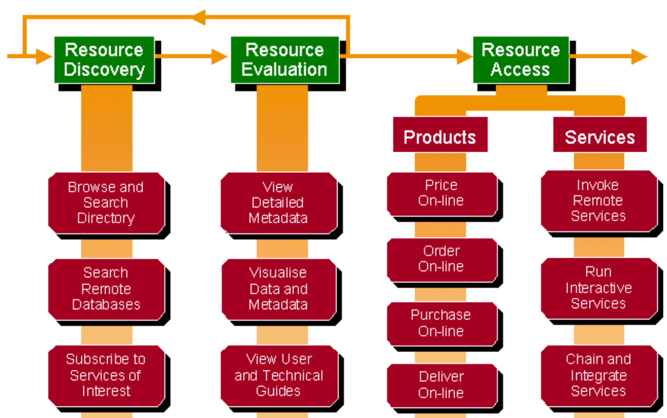

Fig. 2. Geospatial Resource Access Paradigm [6]

This access paradigm illustrates the actions and steps that a user (or even other system) should undertake in order to exploit the geospatial resources. According to this paradigm, the user is provided with some means for the construction of a restriction and the visualization of the corresponding results. After that, he has the possibility of browsing them in order to determine their relevance. If something suitable has been found, the user can continue with a detailed evaluation of the item and eventually with an access to the underlying geodata. Otherwise he can turn back to the discovery phase. Here it is important to emphasize the following points regarding the systems to be built with this paradigm:

- These systems must enable users to find the information they need as fast and easily as possible. Therefore, the conceptual model has to take into consideration the domain of the user and the search facilities have to be intuitive, flexible, powerful and close to the user language. In order to help users improve their ability to specify a restriction, some constructions can be provided, for instance: flexible Boolean searching, stop lists, thesaurus, maps, synonyms, high level concepts to search for, and so on.
- The presentation of results has to be carried out in several steps, supplying in each phase the appropriate amount of information needed to make a choice. Besides, the system should sort the results using some kind of ranking for the importance of each item. It also would be desirable for the system to look not only for exact matching results but also for similarities.

Typical search services evaluation

Some of the most popular search services readily available on the web are the ones provided by the National Geospatial Data Clearinghouse. In fact, these search services are usually taken as the reference and archetype for geospatial discovery tools. This section is devoted to their evaluation.

In Fig 3 a typical user interface for the Clearinghouse search services is presented. The user interface lets us not only see how the user has to interact with the services, but also lets us take a glance at the inner functional level and the conceptual model used.

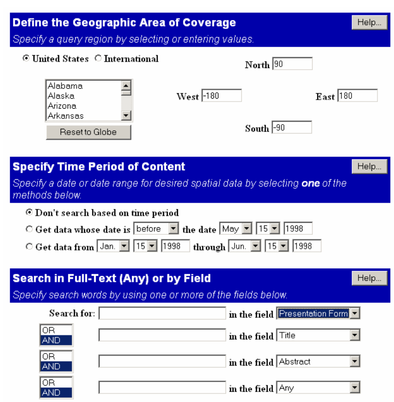

Fig. 3. NGDC search services interface

The first thing that stands out as we take a look at the user interface is the fact that the search specification is carried out in three steps: *Area of Coverage*, *Time Period of Content* and *Search by Field*. This method can be of some interest for the GIS specialist but we neither consider it adequate enough for more general users nor do we see the necessity for those specific steps. Additionally, the impression is that the conceptual model is tightly driven by the underlying metadata level, even to the extent of making explicit use of the structure *attribute-value* pair present in metadata. The consequence is that the user has to cope with low level concepts directly taken from the metadata standards (*Theme.keyword, Citation.Title, etc*) and not with the more abstracts ones he is used to. This can be seen in the Fig. 4, where the concepts water and title relate directly to a metadata value-attribute pair. This low level of abstraction is almost inevitable during the first phases of any technical development, but as the technology matures, there must be a tendency towards low level details independence.

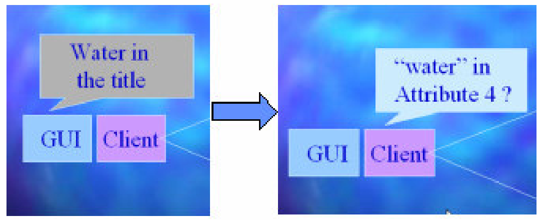

Fig. 4. Example of user concept to metadata value-attribute pair translation

The next aspect to evaluate is the presentation of results. An example of results presentation is displayed in Fig 5:

Fig. 5. Example of results presentation

It should be clear that the first level of presentation of results is not informative enough as to let the user determine the relevance of each item. The title is hardly enough to assess the relevance of each dataset. In addition to this it is difficult to infer any sort criterion for the results. All in all, the general impression is that the presentation of information lacks an end user perspective.

Towards a new brand of search services: User Requirements

After having evaluated the main drawbacks of typical search services, a study to better understand the needs of typical users is convenient. This is so because, although it is clearly stated in some SDIs that their search services are aimed at GIS specialist, the fact is that more and more non-technical people are getting into the GIS field. The problems arise when these new users have to face the complexities of those search interfaces and conceptual models and their low level details.

In order to understand the needs of general users we subscribed to a GIS interest group and started analysing the usual requests. In doing this, we adopted a top-down instead of bottom-up approach, letting the concerns of the users drive our efforts. One of the first things we realized was that, although there was a great diversity of queries, all of them had been formulated using high level concepts. For instance:

- "I would like to obtain a street map of Barcelona, in digital form, free of charge if possible."
- "Does anybody know where I can find information about the earth surface covered by snow?"

- "Where can I find free charged images taken by the Caribbean satellite?"
- "I would like to get aerial pictures of Iraq."
- "Does anybody have the AVE railway layout at 1:1.000.000 scale or higher?"
- "I need statistical information about the primary sector in Aragon at municipal scale and in dbf if possible."

As it can be observed, the typical requests are not formulated using low level details. We still haven't found a user issuing a query resembling this one:

- "I would like a geodata whose metadata information contains the word 'hydrology' in the field *Theme.keyword* or in the field *Citation.Title* (or even in *Abstract*) and 'digital map' in *Presentation.Form* and 'Huesca' in *Place.keyword*."

A typical user does not usually think that way, but:

- "I would like a hydrologic map of Huesca."

Some could argue that any user should be capable of translating his desires into something suitable given a specific search interface. Our experience says that this is not usually the case. Examples abound of great development efforts which came to nothing due to the semantic gap with respect to users. The slightest detail, almost insignificant for developers, can turn into the difference between acceptance and rejection. And a semantic gap is not that tiny detail: it requires substantial effort from users who are not accustomed to technical details.

Towards a new brand of search services: Development

Finally, this section describes the higher-level approximation for the creation of search services taken by our team. This approximation is driven by the following objectives:

- An increase in the level of abstraction of the interfaces.
- A more informative presentation of results.
- A special focus on client-side component-based development as a means of speeding up the development cycles.

Increasing the level of abstraction

A great deal of users abhors complex interfaces which require the knowledge of low level details. They do not want to tackle with complicated steps in order to issue a query but prefer simpler, Google-like ones as far as possible. According to this, our first objective is to increase the level of abstraction of our interfaces. Different areas of application of this principle are shown next.

First of all, we intend to provide the users with more complex concepts to look for. Each high-level concept includes several lower level ones taken from the metadata fields. For example, Fig 6 shows a general search interface, in which the value introduced by the user is looked for in all Dublin Core fields of the metadata [7].

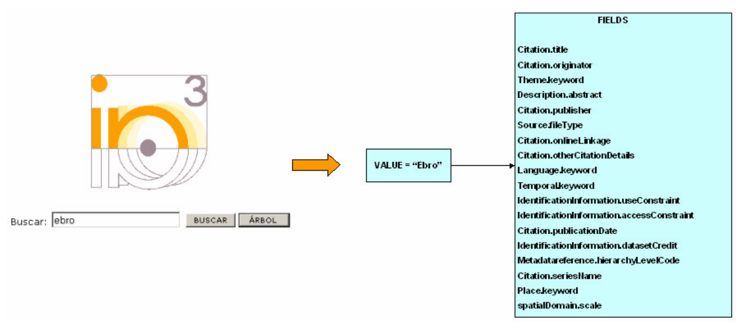

Fig 6. Conceptual mapping in a general search

Another example of a high-level concept is *theme*, which binds to the *title*, *abstract* and *theme keyword* fields of the metadata, so it is worth noting that the concept *theme* has different meanings depending on the level of definition. In general, this sort of concept generalization can be applied thoroughly to all user-level concepts.

On the other hand, this increase in the abstraction level can also be applied to values, not only to search concepts. Fig. 7 shows that when a user asks for *infrastructures,* the system is really asking for a series of lower level concepts included under the term *infrastructures*.

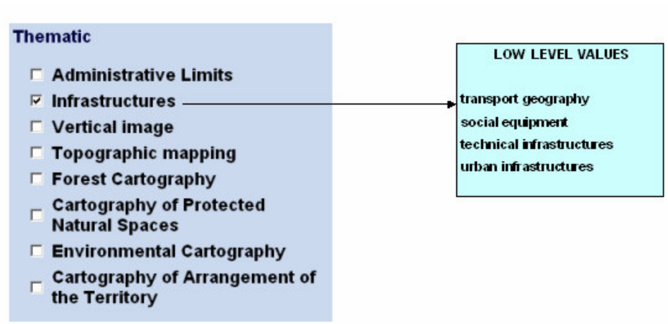

Fig. 7. Abstraction increase in values.

Improving the presentation of results

After having issued a request, the user expects to get the more fitting results in terms of precision but also the adequate information to assess their suitability. Showing only the title is not generally enough, nor showing non relevant metadata fields. In addition, the complete matches have to be shown first but other results with some level of partial matching should also be included, as may be the case with Boolean searching.

In order to achieve those objectives, our team has implemented a prioritisation mechanism to rank the closeness of a match. The underlying premise is that, depending on the search type, certain fields are more relevant than others. For example, in a thematic search a match in the metadata field *Theme* is more important than a match in *Abstract*, so those results that have the value asked for in *Theme* have to be shown first. Fig. 8 shows the first results of a general search with the value "*canales*" (Spanish word for canals). The first results have the value in their titles, whereas the forth and following have that value in less important fields, for example abstract. It can also be observed that the system displays the minimum necessary information for the user to make a choice.

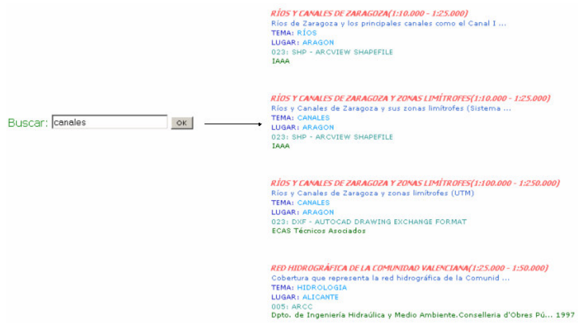

Fig. 8. Example of sorting the results according to their relevance

In case of Boolean searching, each match of a value in a field increases the priority of the item so the results with more matches in more relevant fields are shown in first place. It is worth noting that even results with partial matches are included, albeit down in the list.

Finally, an alternative way for structuring the results using tables is also provided. This method helps users in making comparisons and even in exporting the information to other applications for further processing, as seen in Fig. 9, in which the user can save the table in an Excel style sheet.

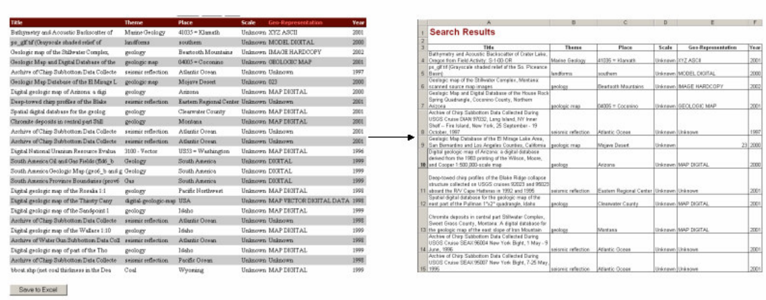

Fig. 9. Showing results using tables

Client-side component-based development

Given the great variety of users, it is important to devise a system architecture flexible enough as to adapt easily to different scenarios. A typical enterprise application is structured in three layers: presentation, business and data. The deeper the layer, the more costly to change. The data layer addresses information storage and access functionalities. To create this layer, data has to be modelled and the storage mediums designed. Any modifications to this layer must be thought of carefully. The business layer does just what it implies: it performs business logic. Here data is manipulated, transformed and converted. This layer is easier to modify than the data layer, but still implies a great effort. Finally, the presentation layer generates the user interface and must be able to serve multiple types of users. This is the easiest to modify layer and the focus of our efforts to adapt to different users.

The presentation layer contains a series of components developed using different technologies such as JSP, XML, XSLT and client-side Javascript. The strong point about this layer is that their components can be added, modified and selected dynamically without any impact on either the business server or the data layer. This way, the system is more readily adaptable to users needs. Fig. 10 presents a simplified architectural view of this layer.

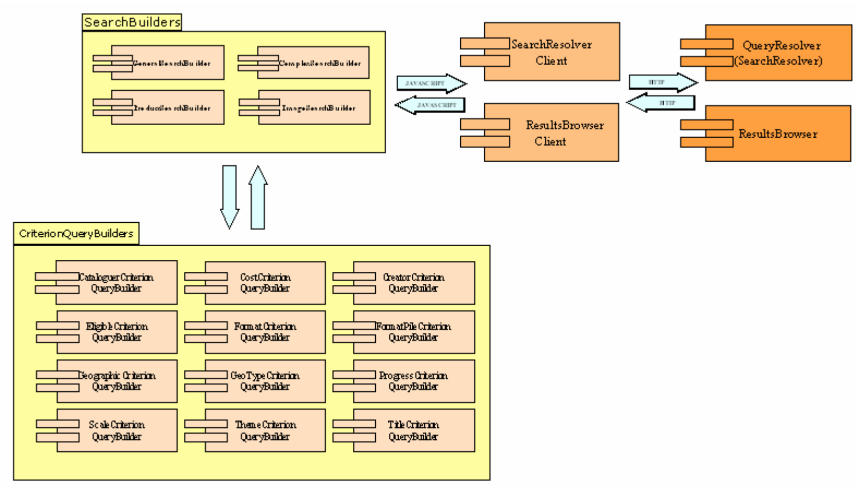

Fig. 10. Architectural view of the presentation layer

Depending on the type of user, the client will receive a concrete *SearchBuilder* adapted to its needs, for example a user interested in looking for geospatial products will receive a *ProductSearchBuilder*. Moreover, each *SearchBuilder* will make use of a series of *CriterionQueryBuilders*, each of which is responsible for creating a request based on a concept (*theme, place, cost, etc)* and a value. Finally, the *searchBuilder* will delegate on a proxy to send the query to the servlets in the remote servlet.

Conclusions and future work

As the variety of user types getting into the GIS field increments and diversifies, the need for better and more comprehensible spatial data infrastructures increases. Nowadays, GIS-related Web sites that provide metadata search facilities have to enhance their services in order to adapt to the demands of new users. Search services based on the direct association of metadata attributes and values are no longer enough. This work has proposed a new approximation for the creation of search services based on the increase in the level of abstraction of the interfaces and on client-side component-based development. In this way, users can express their needs using problem-domain concepts and new services can be provided in a flexible and fast pace as new requirements arise. The final result is better system usability and overall user satisfaction. Nonetheless, much work is needed yet. The number of potential users of geospatial information is immense and more and more data is being collected. Our team at the University of Zaragoza is investing great efforts in this field to keep abreast with the new challenging demands.

Acknowledgements

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