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Toward user oriented semantic geographical information systems

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Toward User Oriented Semantic Geographical Information Systems[1][*][**]

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Abstract. *User Oriented Geographical Information Systems*, a recent adaptation of classical GIS concepts to everyday usage, are becoming more and more present in the web landscape. Recent developments show the need of adding higher semantic levels to the existing frameworks, to improve their usage, as well as to ease scalability. We point out limits of actual examples, related to handling heterogeneous data, scalability issues, and expressiveness, and suggest a framework for building a *Semantic User Oriented GIS*. Notably this framework aims to address the peculiarities of the geographical space domain, and to offer a cognitively sound interface to the user.

1   Introduction

Over the last 20 years, Geographic Information Systems (GISs) have become part of a wide range of computerized applications in a variety of fields; tracking the migration routes of animal populations, identifying the effects of oil development on ecologic systems, aiding farmers to regulate their use of pesticide, or corporate supply managers to predict optimal locations for distribution warehouses. However, if initially intended for institutional planning and analysis, the growth of the internet has recently brought GISs in an unexpected light; users start to expect the same level of comfort found in other successful web applications, i.e. available geographical tools have to be easy to use, free, and to provide transparent access to services and information.

The Semantic Web intends to address these needs on a more global scale, by creating an universal medium for information exchange, by giving meaning (semantics) to services and content on the Web [1], in a manner understandable

by machines. However, in the user GIS domain, if we all browse mapping websites to find out where our friends live, or where a particular event takes place, we still seem far away from the Semantic Web ideal of seamless access to information and services backed up by geographical representation as described by the seminal semantic web dream.

Alongside this effort, web services promise to turn the web of static documents into a vast library of inter-operable running computer programs. As such they have attracted considerable interest, both from industry and academia. Current web service technologies are, however, relatively inflexible and ongoing research is investigating how semantic web technology can alleviate this. A good candidate technology for service integration are Semantic Web Services, which, over well endorsed Web Service standards (SOAP, WSDL [3],...), propose a flexible framework of semantic components. A promising semantic web services framework is WSMO [10] which describes web service invocation, choreography and orchestration through the use of four types of components - *goals*, *ontologies*, *web services* and *mediators* - which allows for goal based service discovery and interoperability. A testbed implementation of this standard is the IRS-III server [4].

This paper, which introduces work in progress, briefly presents in section 2 actual GIS usages and trends, pointing out the issues regarding semantics and interoperability, before sketching in section 3 a framework designed to overcome these difficulties.

2   Geographic Information Systems

A GIS is a system for creating and managing objects composed of *spatial attributes* (polygons, nodes, maps, etc) as well as *descriptive* ones (names, numeric values, etc). In the strictest sense, it is a computer system capable of integrating, storing, editing, analyzing, and displaying geographically-referenced information, usually stored in a so called *spatial database*. In a more generic sense, GISs are 'smart map' tools that allow users to create interactive queries, analyze the spatial information, and edit data.

A typical example of GIS usage would be to compare meteorological and terrain information of a landscape involving cities and rivers in order to evaluate the probability of floods. This information can further be combined with census data relevant to the city and the results may indicate the need of taking measures in order to avoid probable floods or help planning emergency scenarios.

Hence a GIS, though using maps to display synthetic information, is different from the simple mapping systems available on the web, which usually allow the user to spot an address, or to get directions from one location to another. Recently, however, this distinction started to fade, with the appearance of freely customizable mapping frameworks and APIs which allow developers to add custom information to maps ([6], [11]), by collecting data from standard documents like *rdf* files, or simply by *ad hoc* 'web scraping'. This allows to represent the location of events (concerts, exhibitions, etc.) or 'things' (banks, hotels, etc.) on

maps (examples on [9] and [12]), information more relevant on a day to day basis to the user than, for example, flood statistics.

These embryonic GISs are here referred to as *User Oriented GISs* (*uGISs*), since they aim to address only *specific* user needs, and stand in contrast with professional GISs, which usage can adapt, at the cost of complexity, a wider range of tasks but.

uGISs, modulable and open, arguabily represent a first example of truly distributed GISs; allowing developers to *hack* functionality on top of a robust mapping framework gets GISs seems to designate GISs to the same exponential growth that made the web successful. However the actual development scheme is limited by several factors:

− *Data Heterogeneity*. In hand crafted uGISs each new data source has to be integrated in an *ad hoc* way, which seriously hampers the scalability of the process.
− *Lack of Semantics*. When data is not integrated by hand but dynamically, the lack of semantics and of reasoning capabilities limit the amount of knowledge which can be extracted from the collected features.
− *Expressiveness*. Ease of use of the system is obtained at the cost of expressiveness, i.e. only a few queries are available, often only the filtering of features displayed on the map, or very simple natural language interfaces[1].

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[1] These three shortcomings are exemplified by a simple experience on a famous website, which mixes ad hoc integration with web page analysis and offers a simple natural language query system. As for November 2005, the answer to the query 'hotels near lax', advertised on the service's main page as an example to try, indeed returned a list of 10 hotels situated close to the airport. However the first results to the similar query 'pizza near lax' where situated further than the next 10 results, whilst the query 'great sushi near lax' surprisingly returned a chinese restaurant situated more than 22 miles from the airport, together with a a traditional american food restaurant, serving hamburgers, pizzas, sandwiches and steaks. We found out later that the restaurant was refered to by a webpage including an unrelated 'top sushi list'. The same query also returns a couple of hotels which, if they were indeed serving sushi, were not particularly renowed for them but which were, according to reviewers, 'a great hotel option for lax parking!' or 'a great choice for business travelers'. Switching queries, if you need to 'buy wine near lax' you will be oriented toward specialized wine shops - some of which more than 42 miles away from the airport (!) - neglecting the fact that you could probably buy a bottle in any food store. Finally the results are not better if one tries to work the semantics by herself, since asking for a 'food store' leads to visit a few pharmacies and that 'food shopping' invites you to several pet food stores.

In an eGovernment context, the queries would be more relevant to official buildings, hospitals, libraries, housing projects, but the basic problems would be the same. We believe that these problems can only be alleviated by using Semantic Web techniques.
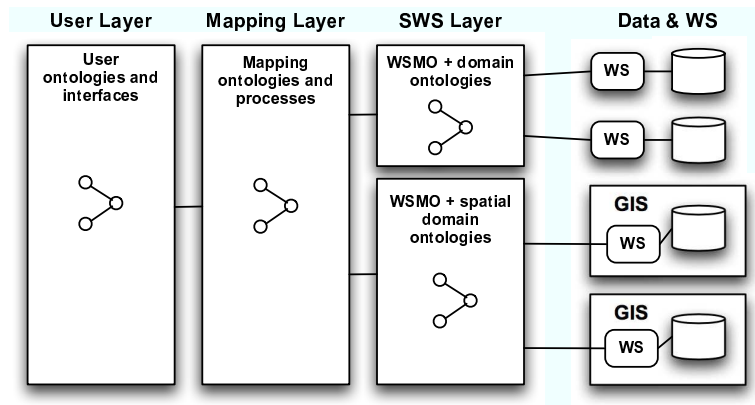
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Fig. 1. Semantic GIS Framework

3   Semantic GIS

A Semantic User Oriented GIS, or Semantic GIS (SGIS), is a system which
answers to geographically oriented queries in an smart way while integrating
multiple and heterogeneous information sources. As such, it needs to address the
previous issues. In order to achieve this a multi layered architecture is proposed
(fig. 1). The components of this architecture will be discussed in turn.

Web Services Layer. The Web Services Layer allows distributed datasets to be
accessed in a transparent manner, and provides basic query operations. Another
advantage of this abstraction is to hide the underlying relational access interface.

Semantic Web Services Layer. The operations provided by the previous layer
can be semantically described using the WSMO framework. However the domain
ontology has to be adequate to the peculiarities of the spatial domain. This
domain, more accurately called *geographical space*, which contains or is composed
by geographical *features*, as opposed for example to *table-top space*, realm of
manipulable *objects*, is the environment in which we evolve. Basic characteristics
of this domain are that our actions have only limited effect on it (i.e. it is
relatively *static*) and that our perspective on its features may change as we
move through it. The approach to model such a domain is far from generating
consensus. Therefore several ontology modeling approaches will be explored:

- *Mereotopology vs Set Theory*. Is the geographical space not better described
  using *part-of* relationships (i.e. mereologically) and topological relationships
  (e.g. contiguity) than by classical set theory (in which things are *composed*
  of things inside a space) [2]?
- *Regions, Boundaries and Things*. Possession of a boundary is is one mark
  of individuality, but what is the status of boundaries themselves? and what
  about regions in which things are situated? Material objects cannot share

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the same space but it is the case for *fiat*, i.e. arbitrarily or loosely defined, objects[8]. Moreover, should this be extended to processes or events [2]?

– *Graduation and Fields.* Relations such as *closeness*, neighborhood, or limits seem to be better expressed in terms of graduation (e.g. where does a hill start?). This is also the case for *field*-like features such as population density or temperature [7].

User Ontology Layer. Although GISs exhibit various levels of graphical user interface complexity, as well as custom query languages, the underlying data level is often the only way to specify complex queries. Indeed, full GIS usage can hardly be called intuitive and often requires considerable technical formation from the user, or even programming skills. In contrast, nowadays, only basic queries are available to online GISs users. Therefore, building Semantic GISs involves allowing queries which add expressiveness to actual uGISs whilst hiding over technical low-level access.

Also, there is strong evidence that we apprehend our environment in a *qualitative* and *imprecise* way. This cognitive attitude, although introducing what appear to be scientific 'misconceptions', is strongly rooted in our way of perceiving our environment and therefore extends to many of our cognitive schemes (the ones based on some kind of *spatial metaphor*). The study of these ways of experiencing the world is relevant to the emergent *Naive Geography* field [5].

Indeed, if semantic GIS may not offer the precision of low-level spatial SQL queries, they may try to be cognitively sound, i.e. to offer coherent solutions to a set of typical queries with a limited amount of context knowledge. Two important structuring concepts of our perception of geographical space are *journeying* and *places*; we access maps to gather information regarding a journey between a place and another. However the range of useful features and modifiers to this basic framework is virtually unlimited. Here are a few examples:

– Can I buy wine and a Birthday Card in my way to my friend's place?
– Is there any swimming pool close to my place or to the Open University?
– Is Two Mile Ash a children friendly neighborhood?

These examples exhibit features that are geographical and some that are not. In this case translating queries to non geographically related semantic web services is necessary, as well as integrating the results.

4 Conclusions and Future Work

Our aim is to further investigate the particulars of this framework, by exploring geographical space domain ontologies alternatives, building a cognitively sound use ontology, as well as investigating ways of mapping between the two. For the implementation, we plan to use WSMO descriptions of *ad hoc* and available web services. These description, together with the relevant goals, are to be executed by the IRS Semantic Web Services platform. Results are presented to the user, in order to be manipulated by him, through mainstream web components and APIs.

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