A Methodological Approach to The Development Of Applications In A SDI Environment

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ABSTRACT

This paper describes a methodological approach to the development of geographical Web applications operating in SDI environments. The application is firstly modelled by means of a standard methodology and a formal language: UML. The UML data description is then transformed into XML files, with geographical objects described in GML. Finally a transformation to the SVG format is accomplished to visualise and analyse the data through a Web browser. The proposed approach complies with the principles and the technological framework of the Inspire initiative for European SDIs. As case study, an application to analyse the evolution of Alpine glaciers is briefly described.

INTRODUCTION

As pointed out in (Giger & Najar, 2003), one of the main problems in developing applications compliant with SDIs (Spatial Data Infrastructures) is “to formalise a specific part of the information space in order to develop deterministic algorithms to process the resulting data”. In the GIS (Geographical Information System) community, a similar approach for a common description of reality, supported by standard technologies, is still lacking. Furthermore, the added value of a design approach is increased by its ability in describing not only the pool of data concerned, but also (at least some of) the ways in which end users can interact with data, i.e. a framework of services strictly related to the application content, its potential end users, their goals, needs and constraints: language, cultural background, physical condition at the time of interaction.

Within the framework of a geo-spatial Web application, this contribution wishes to describe an attempt to test a methodology that, on the basis of a conceptual model, derives data structures and some basic visualisation elements distributed and accessed through the Web in the technological framework of the XML (eXtended Markup Language) suite. The data are at last presented following the recommendations of W3C for the SVG (Scalable Vector Graphics) specification. The proposed approach complies with the general principles of the Inspire initiative for SDIs, which recommends that (spatial) information be generated, stored and maintained in local and distributed repositories, and also accessed and moved on the Internet in a “neutral” non-proprietary format by means of a set of infrastructural services. Moreover it allows operating directly on data at client side to run the user functionalities.

The approach is tested through an application to analyse the evolution of Alpine glaciers and to distribute related information on the Web. The geospatial application model is described by UML (Unified Modelling Language)[59], a tool recommended also by Inspire for data modelling (Architecture and Standards WG, 2002). The proposed methodology provides for the translation of data expressed by UML models in XML files describing the data characteristics and for the definition of a set of basic

[59] UML is the OMG standard (Object Management Group) since 1997 for information systems modelling.

visualisation elements. The spatial information is coded into a GML (Geography Markup Language)[60] file; visualisation elements can be coded into a SLD (Style Layer Descriptor) or XSL (eXtended Stylesheet Language) file or directly into the GML file (for the version 3.0 only). While the translation of spatial information from UML models to GML has been already investigated (Gronmo, 2001) (Gronmo et al. 2002) (Portele, 2002), the XML coding of sets of visualisation elements is a relatively new issue (Piazza Bonati et al., 2003). This step is essential to produce applications ready to use on a Web client.

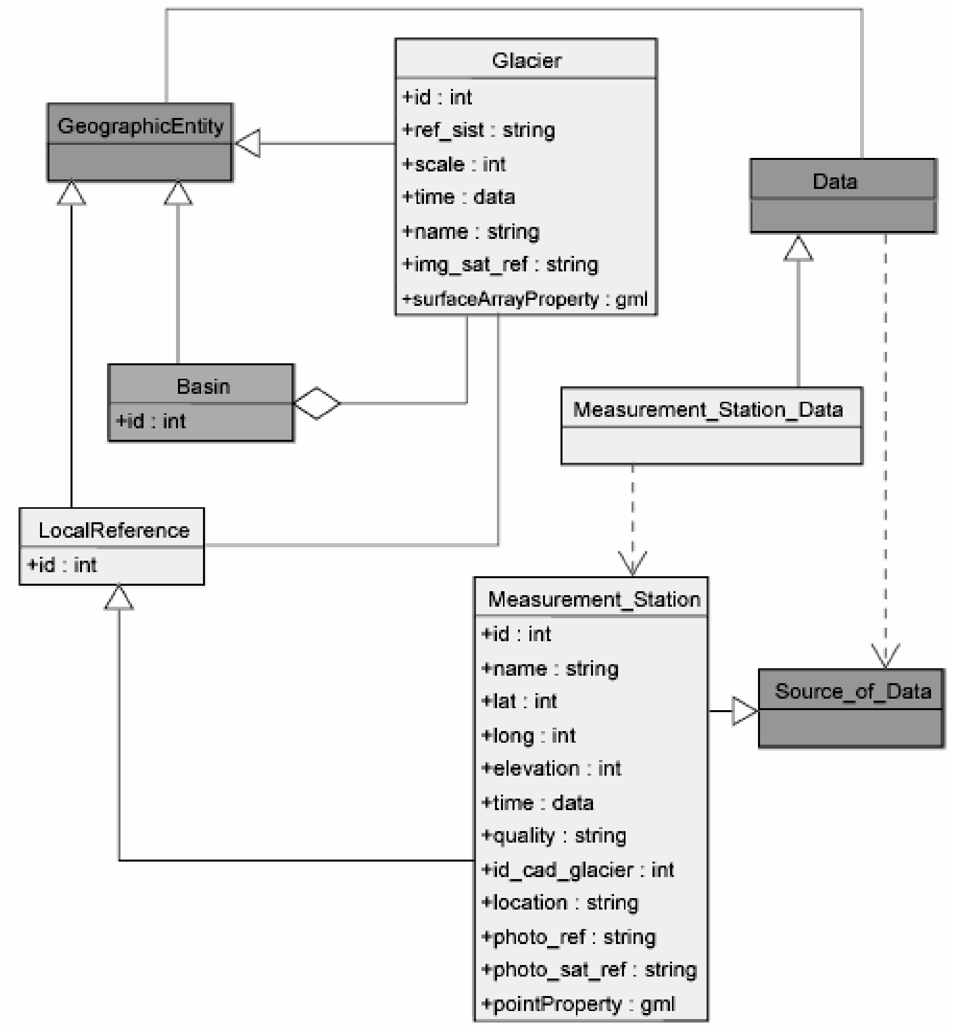

Figure 1: A fragment of the UML description of the application for glacier monitoring.

[60] GML is recommended by the OpenGIS consortium as "neutral" format and is adopted in Inspire SDIs.

FROM UML DATA MODEL TO GML/XSL DATA DESCRIPTION AND SVG VISUALISATION

The aim of the conceptual model is to define the information involved in the application to be designed and its interconnections. The Figure 1 shows a fragment of the model designed for the test case described in the following section. The UML data model is mapped into an XML Schema following a set of criteria derived from the literature and verified in the case study (Gronmo et al. 2002) (Portele 2002) (GML Implementation Specification, 2003):

1. the UML classes are translated into GML complex elements if they have attributes, as simple elements otherwise;
2. the inheritance of classes is maintained if they are related through generalisation: hierarchic tags express this situation;
3. classes connected by an association (such as GeographicEntity and Data in Figure 1) establish a generic connection also with their subclasses (such as Glacier);
4. associations and aggregations are mapped to elements of complex types.

In the UML model the use of sub-classes of classes corresponding to some elements of the GML Schema (by example the classes Glacier, Basin and LocalReference which inherit from the class AbstractFeature belonging to the file feature.xsd) lets to obtain a GML Application Schema, which expresses a vocabulary for geographic objects in the particular domain. The GML Application Schema makes provision for each GML file a single complex feature (*GeographicEntity*) containing a set of other nested complex features describing subsets of aggregated data. Therefore the subclass definition follows from the inclusion of the specific schema definition files. It allows the extension of the basic GML schema (as defined in the specification of the adopted version 3.0) and defines new types for handling the geographical features and the attributes. The schema will be used by the user application to interpret the GML data structure in order to extract the information needed by the application itself. It is also used to validate the GML file.

A further aim is to identify the ways in which data are to be represented and manipulated by some categories of end users. This part of the design can be derived from a specific analysis that takes into account the types of potential end users (in the test case, by example, glaciologists, students, clerks of environmental Agencies, etc.), their different aims (by example, the same user should be interested in viewing the evolution of glacier contours through time, as well as in accessing to all data available on a specific glacier at a well defined date) and needs, preferences or constraints.

After the modelling and design step, there are two files, i.e. a GML file (generated) containing the definition of the geographical objects with their attributes; a XSL file (defined) containing the visualisation rules for the geographical entity representation. These files are used to perform the map styling process by means of the XSLT (XSL Transformations) process: this means that a geometrical-to-graphical transformation and an attribute assignment are done for each GML geographical feature in order to produce the corresponding SVG graphical elements. Possible operations connected to geographical features can be linked to the graphical elements by means of the specification of the appropriate function.

THE CASE STUDY

The methodology proposed has been adopted in the case study of an application developed in the framework of the Project “Italian Glaciers Monitoring from Space” (funded by the Italian Space Agency) aiming at monitoring the changes of some Alpine Italian glaciers by exploiting remote sensing images. Users are mainly operators of the environmental Agencies or Public Administrations with no specific know-how in computer science and GIS so data should be presented in friendly fashions, able to enhance the comprehension of phenomena (the retreat of glacier contours through time, by example) and allow the selection of the data of interest. One of the main aims of the project is to let the users compare the extensions of glacier contours year by year: it is therefore important to allow the overlay of data representing glacier extensions. Another main issue is the easy access to the inventory data associated to each glacier that were collected during on field surveys by human operators and constitute the official reference for further comparison.

By following the above described methodology the data of interest for the application modelled by UML are transformed into GML files which are then prepared for visualisation as SVG data following the criteria formalised by XSL. In this way the users may access from their Web browsers a page presenting as background a remote sensed image of the zone of the glaciers that must be monitored. A set of tools allows overlying on top of the raster image the vector contours of the glaciers corresponding to the observation in different years. The users may vary the style of the glacier surfaces so that it is possible to have a transparent view of the different extensions and improve change detection. It is also possible to easily show the inventory data corresponding to each single contour line: they are presented as a list of attributes.

The users can also perform other operations such as zoom and pan. Another important feature of the application regards the possibility to manage complex objects which are aggregated by hierarchical relations: this is suitable when dealing with glacier as in many cases they are not isolated but can be grouped together to form a ‘group of glaciers’; another possible aggregation corresponds to the hydrographic basins.

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