STRUCTURING 3D NUMERIC CARTOGRAPHY IN GML3

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ABSTRACT

Here is related the beginning of a research developed inside the project PRIN04 coordinated by prof. R. Galetto about " Evolute structures of numeric cartography for GIS and WEB"
The research goal is about the 3D structuring cartography in GML3 to support interoperable generation, distribution and condivision on network of GeoDataBases.
The work it has been articulated, in a first phase of methodological analysis, in order to characterize the existing standard that can be used to improve the quality requirement of the cartographic structure.
Particulary beggining from legislative reference points such as: the detailed lists of written up content of the Technical Committee of Intesa Stato Regioni for the contents of the GeoDatabase, the ISO TC/211 normative for the standardization criteria, the documents about the use of XML/GML and the Open Gis Consortium (OGC). It has been therefore predisposed homogenous cartographic data and it has been verified their quality about the previous standard; particularly it has been analyzed the follow aspects: the definition of geometric-semantic congruence and coherence, and the definition of the 3D information data.
Subsequently, from this technical specifics, it has been investigated the translation in formal contents, using an owner interchange software (ESRI), to support some guide lines implementations to generate a GIS3D structured in GML3.
The research focused on conceptual models such as spatial and logic relationship, typologies of geometric object and the ties and relations between the objects which allows to define a geometric structure based on topologic proprieties.

1. INTRODUCTION

Codifying and uniforming informatic data is one of two bigger problems for data producers and employers. Therefore, also the field of geographic information shows its proper needs of uniformity and interoperability among different types of data.
In particular in the cartographic field, it has been moved from the traditionally paper-drawn cartography to a numerical one and then to the management of structured topographic DataBase. From this moment on, we have the need to solve the problem of the physical structure of the dataset.
In fact, even if DXF and DWG format is universally known for numerical cartography diffusion, the same format is inadequate to transferring data in the new form of GeoDatabase.
Therefore, Open Gis (OGC) Consortium has developed the Geography markup Language (GML), apposite to memorize and transfer ('via' Web too) geographical data.
Thanks to this new language, various actors could share samely codified data even if very heterogeneous inside themselves because of the different interface software and owner data structure.
At the same time, users should be able to have a transparent access to all data structures developed by software employer, in which the sequence string program has to remain at a higher level: for the next future we can't imagine to teach to all the users to program in XML language and in GML language to generate a base GIS. The research in the future will be implemented to create an elementary graphic interface to filter the string even in case of complex 3d data structure.

1.1 Intro to GML

The Geography Markup Language (GML) is a specific language, based on XML eXentisible Mark-up Language coding, to memorize and transfer geographical data. GML has been formuled in accord with the data conceptual model traced and defined by ISO 19100 specific.
XML technology, very diffused today, can memorize and represent data in a very flexible way, according to a proper syntax, completely independent from the data producer.
An essential property of XML standard is the capability to distinguish the content from its layout, so that the coding refers exclusively to data structure.
So, GML, as every XML encoding, records geographical data in a textual form, indipendently from their visual outcoming. Any user can read these documents, so that using and modifying the given data is therefore easy.
Gml is based on geographic data model developed by OGC. This model describes the reality like geographical entities called *features*; the *feature* is a finished list of properties and geometrical elements.
The properties (attributes) are usually composed by a name, a type and a value. The geometric properties are composed by elementary entities defined at base level from: points, lines, curves, surface and polygons.
The particular structure of this language allows to model even complex objects: in this way, an articulated structure like an airport can be codified through the set of simple object, such as: the terminal, the runway, the car ways and the pedestrian one's.

The basic concept of GML is the feature which is an abstraction of the reality phenomena and components.
As the result, all the elements in which the reality is composed can be explained through set of different features: particularly a geographic feature is a feature to which is associated a position on the Earth.
A property of the GML is the possibility to group all the elements with similar characteristics. These data structures are specified in the *GML Application schema* which is a particular XML grammar developed to describe the structure and the contents of the XML documents.
At an advanced level there is the GML Schema which establish the concepts and the construction used in all the application field.
Lot of these elements implemented inside the XML Schema of the *GML base schema* are object type defined in the specific ISO 19100. The GML base schema establishes a set of pre-defined schema and object which can be used inside the GML *Application schema*.
To describe a specific geographic model trough GML an *Application schema* has to be created extending or limiting the data type defined inside the GML Base schema. For these aim it can be used elements and attributes as defined inside the GML Base schema.
The *Application schema*, as said, is of use to validate the GML document and to define the data structure, and it can be built using a text editor or specialized software in the XML schema editing. In practice using the GML schema as conceptual language it can also be translated directly the XML from a conceptual model defined inside another conceptual language, such as UML.
The GML language defines different entities such as elements, geometries, and so on, through an object hierarchical structure as shown in the UML diagram in the Figure 1.
The most part of applies will use only a part of the objects defined in the Schema at Figure 1. For example if it will have to model geographic elements, it will have to manage the feature schema (feature.xsd), if the features will have measurable properties, it will has to import basicType.xsd o measure.xsd.

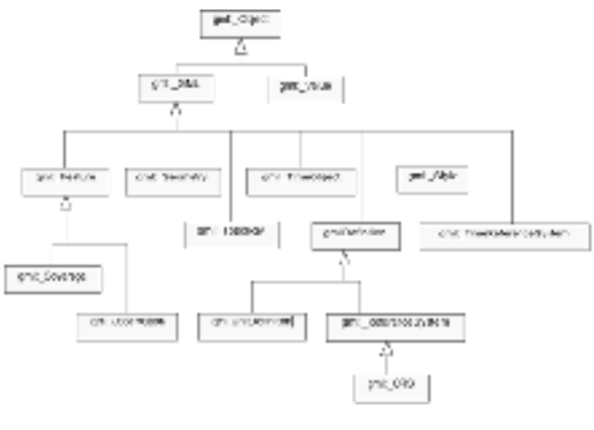

Figura 1. GML hierarchical Class

As the reality, which must be represented, becomes more complicated, more elements will increase the *Application schema*.
A typical GML document will be therefore an XML document consisting of a GML features series: this document is validate through a *GML application schema* that defining the data structure and that is built using and modifying the various objects defined in the *GML Base schema*

1.2 The GML base schema

GML base schema, reached to 3.1.0 release, defines several entities as: geometrical forms, elements, topologies with a hierarchical structure of chart in figure 1
This base schema gives a simple data whole to represent the elements and the connection between them. It's possible to take tools and method also from this schema defining like this new complex kind of data.
For example, feature schema (feature.xsd) is content in the base schema. Using the feature.xsd it's possible to build GML feature and featuresCollection, that are the most important elements of a GML document.

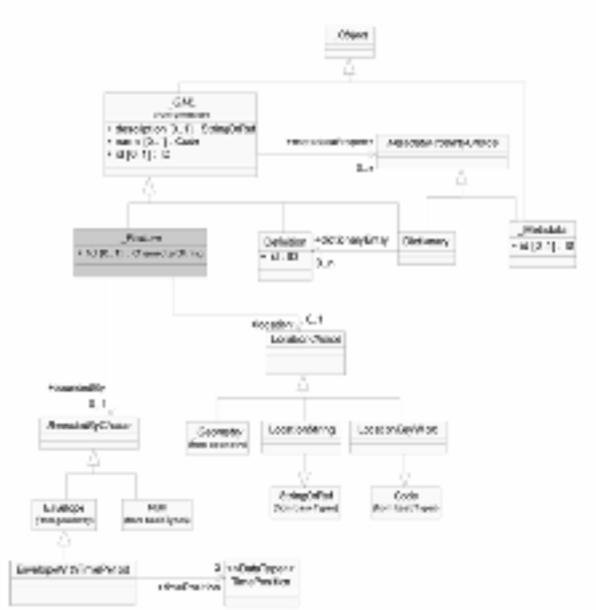

Figure 2 UML diagram of feature schema

1.3 *GML Application schema* creation

A XML/GML schema describes the structure of a XML/GML document, which was to convalidated by an apposite diagram to verify its accordance to the features of the supposed diagram; on this basis, we'll have a valid or invalid document.
This *Application schema* lets the XML/GML document developers to specify structures and contents of a given document and to convalidate it at the sometime.
A GML schema was very complex structure and syntax: the diagram is itself a document written with a GML grammar and has to conform to the *GML basic schema* specified rules.
Developing a *GML application schema* allows the exentinsion or the limitations of basic types and, according to the field of application, the *GML application schema* defines time a time new types of data.
Definitely the several steps for the scheme building are:

- Namespace definition (including the root element)
- Distinction parts between of a given basic schema
- Addition of element to the basic schema, according to the own needs

1.4 GML document creation

In GML, the whole of elements composing a map, can be considered as a group of vectorial informative layer and can be represented with the *feature collection* element which contains information about all the different layer.

In its inside there are all the elements defined at the schema level: here it will be illustrated the most simple case in which there are the only *boundedBy* and *featureMember* elements, the first of which indicates the rectangle of containment, the second of which defines the single elements properties.
The whole of geographical objects are contents of the *feature* element, which is the core of the document, and which contains a subset for geometrical properties, and another for alphanumerical attributes.
The coding of geometry and the properties of an element as a building will be expressed as following:

```
<?xml version="1.0" encoding="UTF-16" ?>
<featuresCollection xmlns:gml="http://www.opengis.net/gml"
xmlns:xsi="http://www.w3.org/2001/XMLSchema-instance"
xsi:schemaLocation="www.isolato.com\isolato.xsd">
  <gml:boundedBy srs_name=ED50>
    <gml:Box>
          <gml:coord>
            <gml:X>106387.98 </gml:X>
            <gml:Y>448375.274 </gml:Y>
         </gml:coord>
         <gml:coord>
            <gml:X>106500.765</gml:X>
            <gml:Y>448783.274</gml:Y>
        </gml:coord>
    </gml:Box>
  </gml:boundedBy>
< featuresMember Fid=”Poligon” Type=”building”>
   <feature fid=”142” Type=”school”
      Description=”elementary_school”>
   <Proprety Name=”floor” type=”Integer” value=”3”/>
 < Proprety Name=”students” type=”Integer”   value=”183”/>
<gml:Geometryproprety featureID=”1” SRS_name=”ED50”  >
          <LRing>
                    <Cdata dimension=”2”>
                    106387.98,448375.274
                    160329.216,448400.84
                    106364.32,448328.637
                    106387.98,448375.274
                    </Cdata>
          </lRing>
      </gml:GeometryProprety>
    </feature >
 </FeatureMember>
</FeatureColelction>
```

1.5 From GML2 to GML3

GML 2.0 can represent geographic information in vector form, but this model has two big simplifications:

- Geographical elements have simple attributes (Boolean, integer, real, string) and geometric attributes
- Geographical elements are defined in a bi-dimensional reference system, linear feature only and not curves are admitted.

The two bigger effects of this are that it’s impossible to create topological connections and to represent the information about the third dimension.
From January 2003 the GML3 version exist; this version gives new important opportunities compared with the preceding version: can represent the spatial elements adding to the preceding linear 2d representation the elements with non linear geometry and 3D, can represent coverages and objects with bidimensional topology and temporal properties. It’s too possible to represent elements with complex properties. It’s keeping to ISO standard.

2 ADVANCED STRUCTURES OF THE NUMERIC CARTOGRAPHY FOR GIS AND WEB

2.1 Project description

The work presented here is a part of a more wide project[*] coordinated from Prof Galetto of the University of Pavia. The final purpose of this project is the drafting of a progress report of a various aspects which concern: the contents about levels of geometric and semantic congruence, the 3D information, the homogenization of numeric cartography coding system and the creation, at national level , of a spatial infrastructure for the management of geographic data.
The advantage of GML is that this language is exentensible and flexible and which lends itself to meet interoperability requirement between different system. This peculiarity is today inexpected because the great mass of geographic data produced through numeric cartography, in a difficult way, can be used by different users without the need of subsequent conversion or manipulation.
Beginning from this question spring the need of a definition of a structure of cartography in GML language at the scope to verify the potentiality of this grammar for the realization of practical application.

2.2 Objectives and metodologies.

In these first part the research goal is been the test of potentially of GML3 as instrument for the storing of geographical data beginning from accurate point of reference as: the general guide lines for the realization of a data infrastructure enunciated by the Inspire organization of European Committee and the specifications compiled by the Intesa GIS[**] for the contents of numeric cartography and the structure of a GeoDataBase.
The first step will be therefore to verify, in a test area, the 3D numeric cartography’s characteristic because today doesn’t exist a complete and exhaustive standard normative for her construction.
Actually particularly in terms of congruence, it’s still to define an unequivocal standard that it allows a direct implementation of data into GIS software which are more advanced and it needs of a best quality informative and semantic content.
After the choice of the cartographic data set it is been evaluated his level of 2D and 3D congruence.
It is obvious that the topological correctness of the data spatial structure is independent from her explict formalization. If the data is correctly acquired the topological property are preserved. This property can do to think that it can realize a data transfer formats that it is able to transfer only the geometry. It is as evident that where this congruence is not verified it must to intervene with function that is able to verify the data correctness.

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* Program research developed inside Prin04 “*Advanced structures of the numeric cartography for GIS and WEB*” (coordinator Prof R. Galetto), Unity B- Polytechnic of Milan “ *Web GIS: sharing of GeoDBase and interoperability of system for distribution of services in the city ambit*” (responsible Prof. R. Brumana)
** “Intesa GIS”: Agreement State-Region –Local Site for the realization of Georaphical Information System, approved by State Region conference in September, 26 1996

When the test area are been individuated and the cartographic dataBase are been tested it will to process at the construction of the conceptual schema for the translation of the data in GML.
The implementation of the schema will have as department point with what it is already be done in the circle of the 'Intesa Stato Regioni' committee. This conference has already defined important reference point for the cataloguing and the storing of geographic data then
In this step of the research one of the objectives will be just the experimentation of the specification content of the "Intesa GIS" and their translation into the conceptual model GeoUML in the application cases.
The begin is the transposition of the UML conceptual model in a application model (still in UML) that it is compatible whit the used data set.
After the creation of the application model it will be implemented the translate in GML. At first, whit the creation of *GML application schema* which it will be the translation in GML of the UML model then compiling the *GML document* on the base of the *GML schema application*.

2.3 Application and instruments.

Starting the experimentation, we are going to transform some elements, taken out from a map of 3D vectorial numeric cartography, representing the city of Milan in a 1 : 1000 scale.
The use of this procedure was born from the need to offer the local Public Administration a new, precise and of high quality product to be used as main instrument for the territorial Computing System.
The structure of many geographical elements respects the whole conditions of congruence, necessary for the management of the same elements inside the GIS softwares.
The contents analysis of the present map concerns a verify of its geometrical structure (both 2D and 3D analysis) and a study of its strata, themes and classes (to value the information level included).
There are different methods to develop the present map and to translate it in GML. They all require data generation and transformation through software and parsers (to create XML documents) and the use of specific GIS softwares.
Commercial GIS software producers developed lately innovative tools for interoperability between systems
These new tools permit the transformation among different format of data : they are particularly able to import and export data in GML2 very easily.

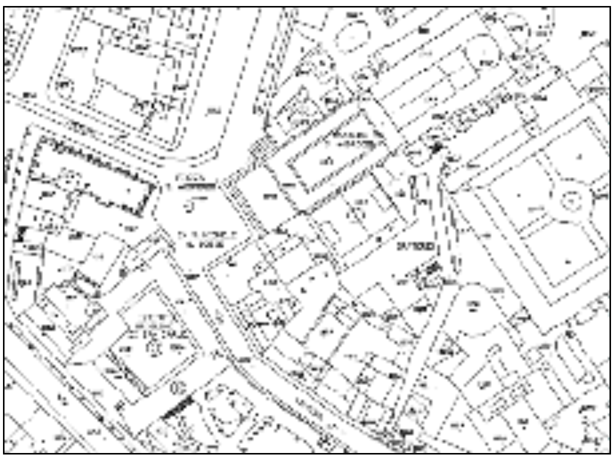

Figure 3 Particular of the 1:1000 scale map of the city of Milan

This map is been analyzed to verify her contents about: the 2D and 3D geometric congruence, the layer, the theme and the objects classes. This work has the scope to evaluate the content of informative level.
For the implementation of the model and for the translation in GML it wants to keep different methodologies which involve both the generation and the transformation of the data through software and parser for the generation of XML documents both using specified GIS software.
Infact the software GIS producer has lately developed interoperability tools between the system which lets the transformation between different data formats. In particular they can to import and export in GML2 without problems
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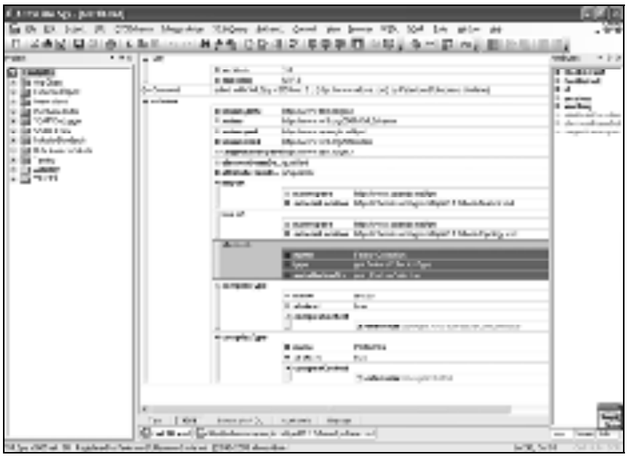

Figure 4 Schema GML implemented with the parser XMLSpy®

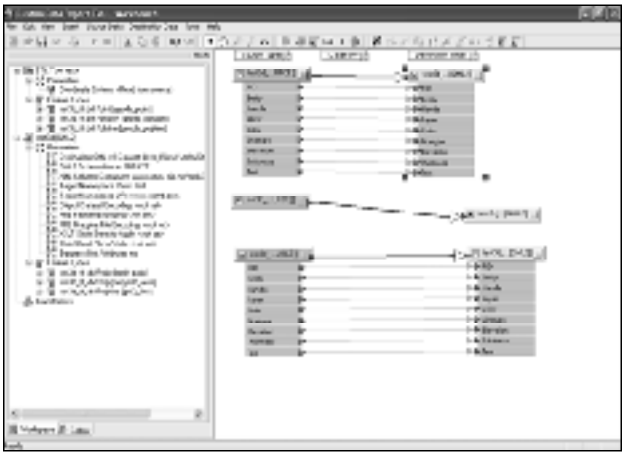

Figure 5 ESRI tools ArcGisInteroperability® for the data conversion in GML2

This new instrumentation will be used to elaborate a prototype in which elements are organized in feature collections, while geometrical properties are taken out from standard GML geometry types

2.4 Future developments.

Before the advent of GML, practically there was no non-proprietary international and standardized exchange format for the vector geographical data.
The GML3 offers a lot more possibilities than the version 2 and probably it will become the most diffused interchange format of geographic data.
The GML is a standard textual format born with the purpose to favour the data interoperability. The GML therefore contain the data but it doesn't explain as the data must be represented. In this paper it don't investigated about the data graphic

representation, this involves the interpretation of the contents of GML with graphic symbol and through style sheet that can be visualized in different format (SVG, VML, XHTML…).
Another open question is about the standardisation, in fact the GML 3.1 still isn't a ISO standard (probably the version 3.2 will become a ISO standard).
Finally the translate from UML conceptual model at GML is still to define completely and more times it must be do "manually". Some research is going on to perform automatic conversion from UML class diagrams to *GML application schema*.
The heat is therefore the development of application and experimentation, in the cartography and in the other fields too, both to testing the potentiality and to exceed the problem of the same language both for the diffusion and the knowledge of this instrument.

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