Taking advantage of Design Patterns in GIS domain

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ABSTRACT

Geographic Information Systems (GIS) are used to collect, store, analyze and present information describing physical and logical aspects of real world entities. They deal with several areas, such as georeferencing, topology, visualization, representation of continuous information and so on.

Most of GIS applications are hardly adapted to new requirements, like changing of the reference system, integrating vector and raster models, or handling continuous information, among others.

This work presents an pattern driven architecture for building GIS applications. The result is a framework that is focused on flexibility and adaptability features.

Keywords

GIS, object orientation, flexibility, design patterns.

1. INTRODUCTION

GIS [5] refers to any application that works using earth-positioned entities. Thus, the core of GIS systems is the positioning system, also known as *reference system*. The earth representation, the axes orientation and shifting, as well as the coordinate system are the essential aspects that have to be considered in order to georeference an entity.

Besides, it is necessary to determine the shape of a geographical object. Topology explains how points, lines, and areas relate to each other and is used as the foundation for organizing spatial objects in GIS. Topology provides a basic language for describing geographic features.

In many situations, the information related to a geographic area is continuous. By continuous we mean information that takes several values, along a continuous domain. Examples of this type of information are temperature, humidity, among others, measured for example in a country. Continuous information is also known as *continuous field.* Most of current GIS can not deal with continuous information by themselves. Generally, they have to be helped by mathematical applications.

All that information should be shown to the end user in a friendly way. *Visualization* in GISs has a major roll, helping the user to understand geographical phenomena.

In this work we present an object oriented architecture that addresses all the above mentioned issues. Our design was guided by applying Design Patterns [2], in order to maximize the model's flexibility. Our model has been successfully used to build a powerful GIS that allow us to change, in run time, critical aspects, like the reference system, the representation of continuous information and visualization.

2. THE ARCHITECTURE

Our model was divided in four main pieces. The first is aimed to solve the georeferencing problem. The second is the Topological Model, which allows defining the relationship between geographical objects. The third deals with continuous fields, allowing to define and to operate them. Finally, we have a visualization model that let us customize geographical entities's aspects according to the context.

2.1 The Reference System

Georeferencing is the core of any spatial information system. Georeference an object implies to know the exact object location on the earth. Positioning objects involves considerations of:

1- The geometric character of the reference system.

2- Measurements metrics.

3- Types of reference systems (Cartesian or Polar).

4- Nature of the origin (an ellipse, a sphere, a point, or whatever).

Due to the irregular shape of the earth, there are many ways to represent it. In fact, each country selects the reference systems that fit better to its surface, according to the shape and location of that country on the earth. The value of the position of geographical entity depends on reference system in use.

Most of current GISs do not allow automatic translating locations between reference systems. Our model provides this functionality, by decoupling the position of the object from the reference system in use.

The positioning system allows changing dynamically the reference system and recalculating the new position. In this poster we present the way in which we took advantage of several design patterns to obtain a flexible and extensible model for implementing most of the reference systems currently in use.

New RS can be obtained by defining a Coordinate System (Strategy) and a Datum (Type Object).

2.2 An OO Topological Model

Besides its position, geographical entities are commonly described in term of its shape. Three basic elements are used to define shapes: point, arc, and polygons. A polygon is defined by set of adjacent arcs; an arc is line between to points. The combination of these three elements defines the topological model. The topological model allows studying spatial properties, like adjacency, connectivity and containment, among entities. A city can be thought as a polygon, it's streets as arcs, buildings as small polygons that are adjacent to streets. There are entities which must be represented by more than one basic topological element such as disjoint polygons or polygons with holes. For instance a country can be represented by a polygon, if the country has islands, the country's shape can be a composite polygon, formed by simpler ones. There is a recursive containment relationship among them.

Our framework makes possible to attach any shape to geographical entities, by enabling polygon and arc composition.

This recursive data-structure was implemented as a Composite.

2.3 Continuous Fields

Continuous Fields are one of the most challenging features to implement within a GIS application [5][6]. Imagine a meteorology application working with data like humidity, temperature and winds, all of them defined in a continuous domain. It is impossible to store the value of each feature for all the points that form the sampling region, the usual procedure is to measure that value, only for most significant positions, that is called *sample.* It will be use later to interpolate the value at unknown positions. The sample is organized in a representation, for instance, a regular grid point, an irregular grid point, a TIN (triangulated irregular network), and so on. According to selected representation, there are several *interpolation methods*, for example in a grid point can be used the *k nearest-neighbors, b-spline* or *kriging estimation methods.* Thus, a continuous field is composed by a set of samples, a representation and an estimation method.

Our design makes it possible to change the representation and estimation method at run time for the same sample set. The representation aspect is a Bridge while the estimation method is a Strategy.

2.4 Visualization

One of the most important features of a GIS application is the ability to show real world entities as they have been defined in the previous sections, i.e., geographical entities having their positions represented using topology and georeferencing features.

In GISs, there are certain situations in which geographic entities have to be displayed in different ways, possibly simultaneously, for instance consider a system that allows the user to view a map at two different scales. The same object can appear in each view showing several dissimilar features.

Besides, there are many powerful graphics engines, like OpenGL, DirectX, VRML, and so on. Our objective was to construct a flexible micro-architecture that would allows us to attach graphical features to each object in different context and show it trough any graphics engine, configuring that on run-time. In order to achieve that, we use the Strategy, Observer, Builder and Strategy Design Patterns [2].

3. CONCLUSION AND FUTURE WORK

GIS can benefit from object orientation to become more flexible and extensible in order to support new requirements. Our future work will be aimed to extend the architecture to support new RSs, Representations and Estimation Methods (for continuous fields) and eventually construct an object oriented query language on top of this architecture.

4. ACKNOWLEDGMENTS

We would like to thank Federico Balaguer for useful comments on draft of this extended abstract.

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