Transforming Geometrically Enhanced Conceptual Model Schemas to GML

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Abstract. Successful implementation of geographic applications starts with conceptual design. A conceptual schema will then be transformed into a database schema that can be implemented. Geography Markup Language (GML) has emerged as an open standard that provides a common grammar for coding geo-spatial content and exchanging over the Internet. In this paper we discuss the transformation from Geometrically enhanced ER model (GERM) to GML. GERM is an extension of the classical ER model that has been successfully used for conceptual modelling of geographic applications. The transformation rules have been chosen such that relevant application semantics is preserved during the transformation. We further present an bottom-up algorithm for transforming GERM schemas into their GML counterparts. A case study is conducted to demonstrate the effectiveness of the algorithm.

1 Introduction

The Geography Markup Language (GML) is an XML-based language defined by the Open Geospatial Consortium (OGC) for storing and transporting geographic information. With the increasing number of web-based geographic information systems, GML is becoming the industry standard for exchanging and sharing information between geographic applications distributed across the Internet. For complex geographic applications, however, the creation of an adequate GML database schema is not easy. It is meanwhile regarded as best practise to design geographic information first at the conceptual level, and then to transform the conceptual schema into GML. Various conceptual modelling languages have been proposed for designing geographic information in the literature [7,8,13,24,25,26]. However, none of them comes without deficiencies, for a detailed discussion we refer to [19].

Motivated by the author’s work on the sustainable land use initiative (SLUI) of the New Zealand government, we have recently introduced a geometrically enhanced ER model (GERM) as our approach to the conceptual modelling of geographic information [20]. The SLUI initiative which addresses environmental problems in New Zealand’s agricultural and silvicultural regions. Whole farm plans (WFP) are a common tool to integrate environmental goals with current farming operations [1,21]. Based on an assessment of available natural resources,
environmental issues are identified and evaluated, and countermeasures are developed. This task involves the capture and analysis of data from distributed data collections such as image data, classification data, spatial data, observational data, climate data, soil data, air pollution data, ecology data, vegetation distribution data, biodiversity data, and business data. The need to adequately model and process geometric properties of data objects involved (i.e., features such as farms, paddocks, buildings, trails, water resources) led us to propose an extension of the popular ER model that supports database designers in dealing with the geometry of objects to be represented in the database application.

We found GERM useful for various reasons. Firstly, GERM preserves the aggregation-based approach [12] of the ER model by means of (higher-order) relationship types [27], thus naturally supporting hierarchical structure. Secondly, GERM allow roles in relationship types to use bulk and choice constructors, thus supporting entity sets, lists, multisets, options and alternatives to occur as components of relationships. Using GERM, geometric properties in the application domain can be modelled by attributes that have geometric data types assigned to them. This defines the syntactic layer of GERM that largely remains within the popular ER framework, thus enabling a smooth integration with non-geometric conceptual models. It allows data architects to cope with modelling tasks that involve geometry in a familiar, non-challenging way thereby preserving all the positive experience made with ER modelling. The syntactic layer of GERM is complemented by an internal layer where geometric properties are represented as point sets. Thus, common geometric shapes like lines, rectangles, polygons, circles, Bézier curves, or Bézier patches can be captured in a most natural way. On its internal layer, GERM makes use of an extended algebra that modifies the standard Boolean operators (i.e., union, intersection, difference, complement) on point sets to achieve a higher degree of accuracy for derived geometric properties [19].

Once a conceptual schema has been created (e.g., using GERM) that captures the data needs of some geographic application under development, it has to be transformed into a data model on implementation level that can be stored and manipulated by a DBMS. Today, most popular DBMS have spatial extensions that use GML to import/export data. In this paper we will discuss the transformation from GERM to GML. The mapping from a GERM schema to GML will be guided by a set of transformation rules that ensure that the resulting GML schema conforms to the OGS standard [22].

Our paper is organised as follows. Section 2 reviews relevant contributions on the transformation from conceptual models to GML found in the literature. In Section 3, we briefly summarize basic ideas of GERM and GML that are essential for the transformation. In Section 4, we introduce rules for the transformation from GERM to GML. We use examples from whole farm plan modelling to illustrate our approach. Finally, Section 5 concludes the paper and makes suggestions for future research.