Chapter 2.20
Semantic Web Rule Languages for Geospatial Ontologies

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ABSTRACT

Geospatial ontologies have a key role to play in the development of the geospatial-Semantic Web, with regard to facilitating the search for geographical information and resources. They normally hold large volumes of geographic information and undergo a continuous process of revision and update. Limitations of the OWL ontology representation language for supporting geospatial domains are discussed and an integrated rule and ontology language is recognized as needed to support the representation and reasoning requirements in this domain. A survey of the current approaches to integrating ontologies and rules is presented and a new framework is proposed that is based on and extends Description Logic Programs. A hybrid representational approach is adopted where the logical component of the framework is used to represent geographical concepts and spatial rules and an external computational geometry processor is used for storing and manipulating the associated geometric data. A sample application is used to demonstrate the proposed language and engine and how they address the identified challenges.

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INTRODUCTION AND BACKGROUND

The Internet is the single largest information resource in the world that is however still not being used to its full potential. To fully unlock the potential of such a large knowledge resource and to enable its effective utilisation by both human and

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machine agents, information on the Web needs to be machine-understandable using semantic as opposed to syntactic (e.g. HTML) markup languages and tools. At the heart of this vision are ontologies which, in the context of the web, are logical theories that act to constrain and derive information (Guarino,1995). They provide the necessary semantics and machine understanding to the sheer volumes of information contained on the Web.

A significant proportion of information resources on the web are geographically referenced. Nearly 17% of all web queries contain place names (Sanderson & Kohler, 2004) and the web, powered by the simplicity of recent applications such as Google Maps, is increasingly being seen as a medium for the storage and exchange of geographic data in the form of maps. A geographic or geospatial ontology is a model of terminology and structure of geographic space as well as records of entities in this space (Egenhofer, 2002). This chapter considers the development and management of geospatial ontologies on the Semantic web. By analyzing the nature and complexity of the geographical concepts and data to be handled by these ontologies, we evaluate the suitability of the current semantic web tools and suggest an appropriate platform to represent and develop these ontologies.

In particular, geographical concepts are complex, normally associated with geometric representations of their boundaries and location and exhibit implicit spatial relationships that need to be computed and derived. Qualitative spatial reasoning as well as computational geometry procedures are both established complementary techniques for the representation and manipulation in this domain. In addition, maintaining the spatial integrity of large geospatial ontology bases is crucial for their realization. Ontology representation languages such as OWL are limited in their ability to handle the challenges in this domain. In this chapter, a survey of current approaches to integrating rules and ontologies is presented. Two approaches are identified, namely a hybrid approach where both systems of ontologies and rules are kept distinct and communicate only through an interface, and a homogeneous approach where one system is mapped to and becomes accessible from the other.

In the second section, we first discuss the representational and manipulation challenges facing ontology management systems that aim to support geospatial domains. OWL as an ontology representation language is evaluated against those challenges and the need for a integrated rule layer is highlighted. In the third section, current approaches to integrating rules and ontologies (logic programming and Description Logic) are identified and classified. Based on a comparative evaluation of both approaches, a homogenous approach to integration, namely, Description Logic Programs is chosen as a suitable platform for the development of geospatial ontology management systems. In the fourth section, the potential and further extensions of this new approach are described. In the fifth section, the implementation of the approach is briefly sketched and demonstrated using a sample geospatial ontology described in the chapter, followed by conclusions and future outlook in the final sections.

MANAGING GEOSPATIAL ONTOLOGIES

In this section we consider a typical geospatial ontology model, as shown in Figure 1. The model is based on OGC guidelines for simple geographic features, see (OGC Technical Committee, 1999; Vretanos, 2005), and other models commonly used in existing geospatial ontology development (Fu et al., 2005, Smith & Frew, 1995). The terminology of the geo-ontology is relatively plain with regards to the number and type of constructs used. This reflects typical geographic ontology developments which, beyond the complex representation of geometry, are relatively sparse (parsimonious (Jones

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