Chapter 3
Toward an Architecture for Enhancing Semantic Interoperability Based on Enrichment of Geospatial Data Semantics

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Abstract
Semantic interoperability is needed to support meaningful data exchanges in distributed environments such as ad hoc networks of geospatial databases and geospatial web services. Even with the increasing popularity of ontologies to capture semantics, semantics of geospatial data are often too weak to support meaningful exchanges. In this chapter, the authors argue that semantically weak geospatial data can be enriched to enhance semantic interoperability. They propose a conceptual architecture designed to support enhanced semantic interoperability in dynamic networks that focuses on semantic enrichment. The proposed conceptual architecture includes a coalition management module, an ontology enrichment module, and a semantic mapping module; the modules perform different types of semantic enrichment and can support various semantic interoperability tasks. Within the different enrichment methods, the authors explain the role of global ontologies, arguing that they play a key role in a semantic interoperability framework. Finally, the authors illustrate with an application example the possibilities of such architecture.

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INTRODUCTION

In GIScience, ontologies are employed to capture the concepts and meanings that are considered valid to describe the geospatial domain (Fonseca, Egenhofer, Agouris, & Câmara, 2002a; Bittner & Smith, 2003; Brodeur, 2004). According to a review by Agarwal (2005) on the role of ontologies in GIScience, increasing interest is given to geographic ontologies. The idea of a universal ontology of geographic space has been studied in several researches (Bittner & Smith, 2003; Čeh, 2003; Kuhn, 2003; Grenon & Smith, 2004). A universal ontology of geographic space would certainly play an invaluable role, given that in GIScience, reference ontologies are also considered as a standard that supports translation between different geographic information systems or negotiation of meanings between communities that use different vocabularies (Agarwal, 2005).

However, there is currently no comprehensive, universal geographic ontology (Timpf, 2002; Agarwal, 2005), and this is partly due to the fact that GIScience is evolving discipline that draws from several other disciplines. Nevertheless, some global ontologies, which capture concepts of a high and generic level of abstraction, independently of the domain of application (Guarino, 1998; Kashyap & Sheth, 1998; Brodeur, 2004), are certainly useful for a variety of tasks, including tasks related to achieving semantic interoperability. For example, OpenCyc, which is part of the Cyc project that aims at creating a comprehensive ontology and knowledge base of common sense knowledge to support human-like reasoning of Artificial Intelligence (AI) applications, contains spatial concepts related to direction and orientation relations, relative position of objects, mereological relations, etc.

ISO TC204, document N271 provides a currently well-known definition of interoperability: interoperability is “the ability of systems to provide services to and accept services from other systems and to use the services so exchanged to enable them to operate effectively together.” Semantic interoperability is also defined as the “knowledge-level interoperability that provides cooperating businesses with the ability to bridge semantic conflicts arising from differences in implicit meanings, perspectives, and assumptions, thus creating a semantically compatible environment based on the agreed concepts…” (Park & Ram, 2004, p. 597). It is also analogous to human communication (Brodeur, Bédard, Edwards, & Moulin, 2003; Kuhn, 2005). In order to be established, semantic interoperability requires the semantics of geospatial data to be explicit and rich enough; this ensures that differences and similarities in concepts used by different systems can be detected with appropriate algorithms and/or by human experts.

Given those definitions of semantic interoperability, the roles of ontologies and global ontologies in semantic interoperability are multiple. While local application or domain ontologies are employed to define the semantic of resources, such geospatial databases (Brodaric, 2007) and functionalities of geo-services (Lutz, 2005; Lemmens, 2006) global ontologies can act as bridges between such local ontologies (Niles & Pease, 2001; Gangemi, Guarino, Masolo, & Oltramari, 2003). Global ontologies can also be employed to enrich the semantics of geospatial data. In fact, semantic enrichment is needed because poor semantics leads to poor semantic interoperability and misunderstandings between users of different systems, databases or services. More specifically, poor semantics means that differences and similarities between the concepts of different ontologies cannot be detected (Su, 2004); queries posed on instances of those concepts might return unexpected results. For example, consider two concepts with the same name “floodplain,” which instances are both geometrically represented by a polygon. However, in the first concept, the polygon covers both the surface of the segment of watercourse in question and the surface of the connected bank subject to flooding, while in the second concept...
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