Chapter 7
Agent-Based Semantic Interoperability of Geo-Services

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ABSTRACT
This chapter proposes a multi-agent based framework that allows multiple data sources and models to be semantically integrated for spatial modeling in business processing. The authors introduce a multi-agent system (OSIRIS – Ontology-based Spatial Information and Resource Integration Services) to semantically interoperate complex spatial services and integrate them in a meaningful composition. The advantage of using multi-agent collaboration in OSIRIS is that it obviates the need for end-user analysts to be able to decompose a problem domain to subproblems or to map different models according to what they actually mean. The authors also illustrate a multi-agent interaction scenario for collaborative modeling of spatial applications using the proposed custom feature of OSIRIS using Description Logics. The system illustrates an application of domain ontology of urban environmental hydrology and evaluation of decision maker’s consequences of land use changes. In e-government context, the proposed OSIRIS framework works as semantic layer for one stop geospatial portal.

INTRODUCTION
With the growth of Internet, there is an increasing demand for location specific data and analytical solutions requiring Geographic Information System (GIS), to locate and integrate multiple databases. This, in turn, requires federal, state and local government agencies to develop capabilities so that their data can interoperate. For example, a real estate entrepreneur, looking for a suitable location for a new business, would require data that combines GIS data with that of the local government’s zoning and tax incentive areas. Home owners and home buyers, looking for information about environmental hazards, can use E-MAPS that combine data from several sources including the EPA’s environmental data, and the HUD’s (Department of Housing and Urban Development) housing community programs.
Similarly, a water/sewer storm water utility company evaluating the feasibility of a new project to expand the existing infrastructures in mountain areas may need information about geomorphologic formations and associated potential landslide risk from the local and federal government databases.

In an e-Government environment, simple transactions can require interactions among multiple resources possibly from different entities within the government, and meaningful understanding of system architectures and the service compositions. Interagency transactions become simple if the agencies involved in a transaction have homogeneous representation structures as well as the same discourse domain (Malucelli, Palzer, & Oliveira, 2006). A geospatial application can use business services with relative ease if it can understand another application’s service descriptions and representations of workflows and information flows within and across organizations. However, these representations become complicated when one needs to embed complex data structures and models into an application. For instance, suppose we are interested in a mobile commerce application that would provide geospatial information as a prelude to completing a business transaction. The transaction protocol for such an application would require access to and representation of geographic data and models. These models themselves may require chaining of multiple services that depend on service level description of geo-processing models, spatial geometries, spatial analysis and implementation logic. Typical query such as “Find the nearest Italian restaurant along the highway” could possibly be answered by chaining multiple services such as geocoding points of interest, integrating transport networks, creating dynamic segmentation of network, providing routing network, rendering cartographic information and possibly converting text to voice. It is possible to envision integration and chaining of services to provide higher levels of functionality if such services are distributed all over the enterprise and are accessible in a uniform standard manner. (Peng & Tsou, 2003).

This paper proposes a framework for a semantic-level communication between geo-spatial services in business processes and application models. The paper presents an overview of interoperability efforts with specific reference to geo-spatial databases and application models and reviews the feasibility of an ontology-based spatial resource integration to combine the core spatial reasoning with domain-specific application models. Existing industry standards and practices in geo-spatial interoperability are identified. This is followed by a discussion of the role of ontology in explicating the implicit semantics of spatial data models and the need for formalism in descriptions of spatial categories. Use of markup languages for spatial resource description and the tagging of spatial ontology are illustrated. Finally, a multi-agent based architecture (OSIRIS-Ontology-Based Spatial Information and Resource Integration Services) for semantic interoperability of spatial data sets and models is proposed. The architecture is illustrated using an application model that uses domain ontology of urban environmental hydrology

**GIS SERVICES IN THE FRAMEWORK OF E-GOVERNMENT**

The National Spatial Data Infrastructure (NSDI) seeks to build an organizational and virtual network to promote the sharing of spatial data among federal, state, regional, and local government agencies and the private sector. The Federal Geographic Data Committee (FGDC) (FGDC, 2009) is tasked to develop a spatial data and metadata standard as well as to create data clearinghouse. FGDC is also responsible for coordinating the development of a “framework” data (Wayne, 2005). Similar initiatives have been taken by European communities for developing a spatial Data Infrastructure (SDI) (Craglla & Signoretta, 2000). In Europe, an infrastructure for spatial informa-
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