

Chapter 21

Semantic Interoperability of Geospatial Services

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ABSTRACT

This article proposes a multi-agent based framework that allows multiple data sources and models to be semantically integrated for spatial modeling in business processing. The paper reviews the feasibility of ontology-based spatial resource integration options to combine the core spatial reasoning with domain-specific application models. We propose an ontology-based framework for semantic level communication of spatial objects and application models. We then introduce a multi-agent system, ontology-based spatial information and resource integration services (OSIRIS), 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. We also illustrate a multi-agent interaction scenario for collaborative modeling of spatial applications using the proposed custom feature of OSIRIS.

INTRODUCTION

Recent studies have revealed that over 80% of local governments in the U.S. have locational references in their data (Nedovic-Budic & Pinto, 1999) and a majority of local governments use geographic information systems (GIS) technology

to manage spatial data, a trend often described as a “growth surge” (Warnecke, Beattie, Cheryl, & Lyday, 1998). With the growth of Internet, there is an increasing demand for location specific data and analytical solutions requiring 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 entre-

DOI: 10.4018/978-1-4666-2038-4.ch021

preneur, 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 (GAO, 2003). 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.

Agencies in various levels of government rarely coordinate the development of their applications. Consequently there is often redundancies and duplications of data even within organizations belonging to the same jurisdiction (Nyerges, 1989). Users often have to deal with proprietary systems that require the understanding of the systems' native command language, input data format, and output presentations. The problem is further compounded when there is a need for communicating with more than one modeling paradigms or when spatial analysis and modeling techniques are used in application areas for which they were not necessarily designed. In most cases, users' access, inference, and analytical ability of spatial dataset and services are limited by proprietary standards, platform dependence, and incompatibility.

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).

Methodological artifacts, techniques for correct description, and interpretation of resources, collectively known as the semantic layer (Vetere & Lenzerini, 2005), are pre-requisites to high level interoperability in a service-oriented environment. High level or semantic interoperability is of vital importance if collaborative business processes are involved (Padmanabhuni, 2004). A complex collaborative process is often needed to compose complex services like dynamic visualization and query processing of geo-spatial data in real time. The representation of semantic content of space and spatial knowledge has a special significance in information exchange and integration. As representation of spatial features are scale depen-

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