Chapter 18
An Ontology-Based Approach to Support Information Discovery in Spatial Data Infrastructures

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ABSTRACT

Currently, spatial data infrastructures (SDIs) are becoming the solution adopted by many organizations to facilitate discovery, access and integration of geographic information produced and provided by different agencies. However, the catalog services currently offered by these infrastructures provide keyword-based queries only. This may result on low recall and precision. Furthermore, these catalogs retrieve information based on the metadata records that describe either a service or a dataset. This feature brings limitations to more specific information discovery, such as those based on feature types and instances. This chapter proposes a solution that aims to overcome these limitations by using multiple ontologies to enhance the description of the information offered by SDIs. The proposed ontologies describe the semantics of several features of a service, enabling information discovery at level of services, feature types, and geographic data.

INTRODUCTION

In recent years, spatial data infrastructures (SDIs) (Williamson, Rajabifard, & Feeney, 2003) have been adopted by many government agencies as a solution to minimize problems of heterogeneity, and to facilitate geographic data interoperability among different organizations. The popularity conquered by these infrastructures is evidenced by the large number of initiatives taken to develop SDIs worldwide. Spatial Data Infrastructures are being built, for example, in Australia ("Austra-

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lian Spatial Data Infrastructure," 2011), Brazil ("Infraestrutura Nacional de Dados Espaciais," 2011), the United States of America ("National Spatial Data Infrastructure," 2011), Europe ("Infrastructure for Spatial Information in the European Community," 2011) and the world ("Global Spatial Data Infrastructure," 2011).

SDIs aim to enable the users to find easily the data and applications offered by their providers. To attain this goal, these infrastructures offer a catalog service, which can be used by both providers and clients. Providers of geographic data and applications may use this service to publish their resources. The clients of an infrastructure, in turn, may use this service to discover information of their interest. When a client submits a query to the catalog service, the service returns a collection of metadata records that match the query. With this information, clients may evaluate the retrieved resources and access them via their corresponding provider.

Current catalog services make information discovery easier, but also have some drawbacks. The main limitation is that their queries are usually keyword-based only, resulting in low precision and recall. This chapter proposes to improve information discovery in SDIs by using ontologies. Our main contribution concerns the modeling of a set of integrated ontologies that enable to describe formally the semantics of several features of the services offered by a given infrastructure. By using our approach it is possible to provide geographic information discovery at service, feature type and instance levels.

The remainder of the chapter is organized as follow. Section 2 discusses related works. Section 3 provides an overview of the main concepts and technologies addressed in the chapter. Section 4 describes geographic data integration in current SDIs. Section 5 presents the ontologies that aim to improve the information discovery process. Section 6 focuses on implementation issues. Finally, section 7 concludes the chapter and discusses further research directions.

RELATED WORK

Over the years, many works using ontologies were proposed to improve spatial data retrieval in spatial data infrastructures and geographic portals. The main difference between these works is the type of information that is discovered by each one.

Some works have been proposed concerning processing services discovery. Lemmens et al. (Lemmens et al., 2007) defined a framework for semantic interoperability of geo operations. Their work proposes ontologies to describe application domains and spatial features. Besides, an ontology for service classification is described and used to define a taxonomy of geographic services. Their work implements a matchmaker service enabled to discover services and service compositions automatically. By other hand, Lutz (Lutz, 2007) developed an approach that uses ontologies for the annotation and discovery of geo-services. In his work, the description of such services is done through semantic annotation of its input and output parameters, preconditions and effects. A semantic signature is generated to represent this information. During a query processing, a reasoner is used to discover services and service compositions using semantic relationships such as subsumption and plug-in. The main drawback of these works is that they do not address discovery of spatial feature types and data access services. Other important works regarding services discovery were proposed by Rezeg et al. (Rezeg, Laskri, & Servigne, 2010) and Yue et al. (Yue et al., 2011).

Other works, in turn, enable discovery of geographic data access services. Klien et al. (Klien, Lutz, & Kuhn, 2006) perform discovery of geo-services focusing on disaster management. In that approach, the functionality of spatial services is described by application ontologies. Services that implement these features are recorded in the system using metadata based on the Dublin Core metadata standard (Weibel & Koch, 2000). Another approach for discovery of geographic services is proposed by Stock et al. (Stock et al., 2010),