

GEO-ONTOLOGY: A KEY COMPONENT FOR SERVICE BROKERING IN SERVICE ORIENTED INTEGRATION OF GIS

Manoj Paul, S. K. Ghosh

School of Information Technology, Indian Institute of Technology,
Kharagpur 721302, India - (mpaul, skg)@sit.iitkgp.ernet.in

Commission IV, WG IV/3

KEY WORDS: Spatial Data Infrastructure, Spatial Web Services, Service Oriented Architecture, Geo-ontology

ABSTRACT:

With the growing need of spatial data for almost all decision support systems a huge amount of data about earth has been collected. The data being captured use different software tools making them heterogeneous both in terms of storage and access mechanisms. For integration of data from multiple heterogeneous sources there is the need of interoperable access for data. Web service technology exactly fits into that requirement and an increasing number of spatial services are being made available on the web. But general catalog-based service repository is inefficient for providing semantic relevance of the requested service. The application of ontology in the form of conceptual schema for the domain is ideal for context aware service discovery. The application of ontology for service brokering in geo-computation has been studied in this paper.

1. INTRODUCTION

With the growing need of spatial data for almost all decision support systems a huge amount of data about earth has been collected. The data being captured use different software tools making them heterogeneous both in terms of storage and access mechanisms. Also the data are orthogonal restricting its use in some particular application domain. The requirement for sharing of Geographic Information (GI) among a large user-base has been felt for long time.

The need of setting up Spatial Data Infrastructure (SDI) at regional, national and global level has been discussed in the literature. These include the Federal Geographic Data Committee (FGDC) and the National Spatial Data Infrastructure (NSDI), Geospatial One-Stop, and the U.S. Geological Survey's The National Map as well as standards from the International Standards Organization (ISO) for geospatial metadata. The NSDI attempts to bring together geographical information sources from all levels of government and other organizations into a single point of entry for easier access to data.

With the advancements of web service technology, there is a paradigm shift in information sharing among a large scale of distributed users. This method suggests providing the information from multiple resources through a standard interface and hiding the complexity behind the interface for actual processing. The individual information providers are termed as *Service Providers*. The methodology also suggests that a central registry for the available services should be maintained for the *Service Consumers* getting benefit for services discovery. This same methodology can also be applied to spatial information sources also and can be termed as GI Services. Figure 1 shows the general architecture for web service based system.

A *Service Broker* is generally the central focus of any service-based computing. This holds all information about a service necessary for its discovery. Every service provider who wishes to publish a service has to register the service at the *Service Broker*. Designing a *Service Broker* for highly heterogeneous

spatial domain is an important research issue today. Standard forming organization OGC and ISO/TC have defined several standards to overcome the heterogeneity problem in spatial domain. OGC Catalogue Service (CS) (Nebert 2004) specifies a catalogue-based search for metadata for GI services in a standardized format.

This paper mainly tries to answer two crucial questions – *how to find the suitable information* (GI Discovery) for a given task from these diverse information sources, and *how to access those information* (GI Retrieval) once the suitable data source has been found. The usability of ontology for discovering a service (Service Brokering) has been studied.

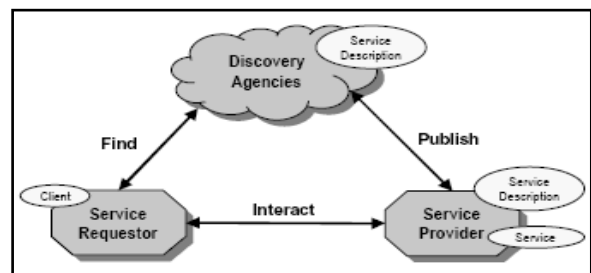


Figure 1. Basic Methodology of Service Oriented Architecture (SOA)

The organization of the paper is as follows: section 2 gives an overview and the standards for service based geo-computation, the usefulness of ontology in discovering a service has been discussed in section 3, finally a conclusion has been drawn in section 4.

2. SERVICE BASED GEO-COMPUTATION

As we turn our focus for service description and discovery, we see that GI services are mostly researched and standardized by Open Geospatial Consortium (OGC). OGC is an international organization providing specifications to integrate geospatial data and geo-processing resources into mainstream computing leads an effort to provide a) standardized protocols for

accessing geospatial information and services and b) standardized service metadata for enhancing the service discovery in spatial domain. OGC has announced many implementation specifications for Internet service of various kinds of geo-spatial data. In the beginning, OGC announced WMS, WFS, WCS, and Catalog services specification to easily provide geo-spatial data on web browser. Catalog Specifications (OGC 2001) provides a way for discovery and retrieval of metadata that describes geospatial data and geo-processing services. It defines a standard mechanism to discover/publish operation and attribute information of geospatial services and presents a domain-specific registry capability for geospatial information. But a number of problems due to heterogeneity make GI Discovery and Retrieval a challenging issue. The heterogeneity problem arises due to heterogeneity in syntax, structure and semantics existing among spatial data repositories.

OGC CS provides key-word based searching methodology for the discovery of service. Since this only considers lexicographical matching for searching, it is bound to be inefficient. Key word based searching method has been found to be insufficient for searching GI services having different semantics. It yields to low precision if homonyms are used for multiple GI Services providing different information. Although WFS wrapper can be used at data provider for getting the application schema of the source data, the semantics of feature attributes may not be sufficient for interpreting its meaning. Thus formation of query for retrieving actual result becomes difficult. To overcome these problems, we adapted the use ontology-based *Service Broker* descriptions of information sources. Ontology-based approaches overcome some of the problems of conventional catalog-based metadata standards by enabling expressive but flexible descriptions.

3. APPLICATION OF ONTOLOGY

The term ontology is used in information systems and knowledge representation to denote a knowledge model, which represents a particular domain of interest. Ref. (Gruber 1992) introduced the term 'ontology' to mean an 'explicit specification of a conceptualization'. Accepting the diversity of geographic data domain, explicit context models can be used to reinterpret information. Ontologies have become popular in conceptual modelling of a system as they can be used to explicate contextual information. In order to make the ontology machine-readable, it has to be formalized in some representation language. A body of formally represented knowledge is based on a conceptualization: the objects, concepts, and other entities that are assumed to exist in some area of interest and the relationships that hold among them. And an ontology provides "an explicit formal specification of a shared conceptualization" (Gruber, 1992), i.e. it facilitates a formal notation interpretable by machines that enables a shared and common understanding of a domain.

Although similar approaches using ontology has been discussed in recent times, its use in a service-based environment has not been adopted much widely. As Service-oriented computing is also gaining importance in GI domain, an ontology-based catalog should overcome the semantic heterogeneity problem. In the geospatial domain, a body of rich knowledge models already exists in the form of ISO TC 211 and OGC standards, which could be used as the basis for developing an already widely agreed domain vocabulary. An ontology method where the shared vocabulary forms domain ontology, all data

providers need to follow the semantics of the domain ontology. Local ontology for each service is also described at the lower hierarchy level named as application ontology. This hierarchical ontology description structure is termed as hybrid ontology (Klien 2004). It has been used for enhancing the services discovery. What we have found is that the use of a hybrid ontology description technique makes the service brokering more efficient (Paul 2006) over normal flat ontology structure or catalog-based service brokering. Any standard logical reasoning tool can be applied on that ontology for the discovery of a service.

The problems for semantic heterogeneity described in the previous section resulting from the fact that the terms from a certain vocabulary (e.g. that used in a catalogue) are just words with an implicit meaning (for humans), but without an explicit meaning (which machines are able to understand). Therefore we propose the usage of concepts that are clearly defined by ontologies to circumvent the ambiguities that otherwise emerge. If a service request is submitted to the service broker (ontology), the broker has to decide which of the registered sources it should use to answer the request. The actual search for a service is performed by mapping the query concept and concepts in different application ontologies. For each application schema there is one application ontology that is described with the shared vocabulary of the corresponding domain. These ontologies provide the formal description of the application schema of a data source. Once the ontologies of the system have been provided, the services can be discovered through WFS *GetCapabilities* request.

The searching procedure for services corresponding to a user's query goes through two filtering steps (figure 2):

- The service request parameters are matched with the shared vocabulary in the form domain ontology. The matching services for the request that does find sufficient matching are filtered from the set of all available services.
- These set of services are further matched with each individual service description with help of the application ontology of the corresponding services.

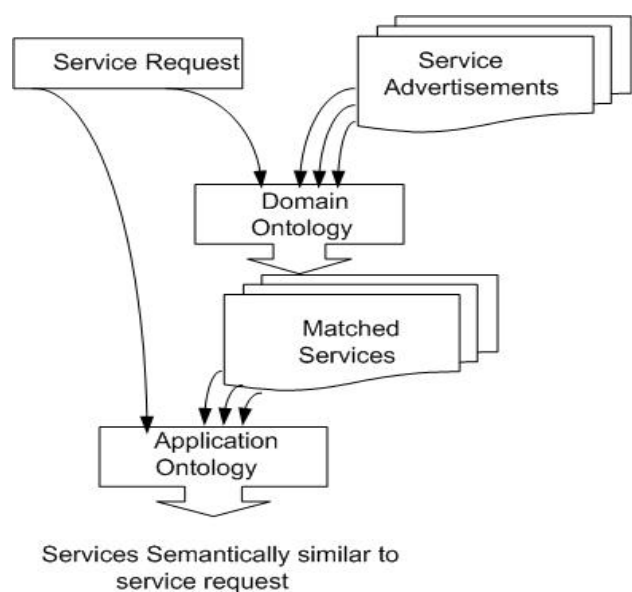


Figure 2. Service Brokering with the help of Ontology

4. CONCLUSION

With the advancements in research for interoperable and distributed systems, the usability of web services has been put into great importance. The advantages of adopting a service-based method lie in its flexibility. A user having no knowledge of the data features needs to find out the required services before accessing the data. Thus the discovery of the services is of much concern. This enables it to easily be adopted into the existing Spatial Data Infrastructure (SDI).

The adoption of service based geo-computation has been standardized by OGC. Although the interface specifications are standardized, it does not provide any semantic aspects for service discovery. We have proposed the use of ontology for service discovery so that a user request can be served based on the context rather than text-based matching.

5. REFERENCES

Gruber, T., 1992. A translation approach to portable ontology specifications. Technical Report KSL 92-71, Knowledge Systems Laboratory, Stanford University, Stanford, CA.

Nebert, D. and Whiteside, A., 2004. Open Geospatial Catalogue Services Specification, v2.0. OGC 04-021r2. Open Geospatial Consortium.

OGC, 2001. Catalog Services Specification, version 1.1, *Open Geospatial Consortium Inc implementation specification*, 28-March

OGCa., 2002. Web Map Service Implementation Specification, version 1.1.1. *Open Geospatial Consortium Inc Implementation Specification*.

OGCb., 2002. Web Feature Service Implementation Specification, version 1.0.0. *Open Geospatial Consortium Inc implementation specification*.

Klien, E., Einspanier, U., Lutz M., and Hübner, S., 2004. An Architecture for Ontology-Based Discovery and Retrieval of Geographic Information. *In the proceedings of AGILE International Conference on Geographic Information Science*.

Paul, M. and Ghosh, S. K., 2006. An approach for service oriented discovery and retrieval of spatial data. In *Proceedings of the 2006 international Workshop on Service-Oriented Software Engineering*, Shanghai, China, May 27 - 28. 6. ACM Press, New York, NY, 88-94.