

SWING – A Semantic Web Services Framework for the Geospatial Domain (position paper)

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Abstract. The ability to represent geospatial semantics is of great importance when building geospatial applications for the Web. Semantic Web Service technology provides solutions for intelligent service annotation, discovery, composition and invocation in distributed environments. Deploying this technology into geospatial web applications has the potential to enhance discovery, retrieval and integration of geographic information, as well as its reuse in other contexts than the original one. This position paper gives an overview of a recently started EU funded project (under FP6-26514) called *SWING* (Semantic Web Services *I*nteroperability for Geospatial Decision Making) – a project which is aimed to investigate the applicability of semantic technologies in the area of geospatial services. The goal is to provide a geospatial semantic web framework that facilitates the employment of geospatial services to solve a specific task in geospatial decision making. In this paper, we emphasize the motivation of the project, its goals, its technical organization, and highlight its potential impact.

1. Introduction and Motivation

Geographic information is an integrated part of every day life and geospatial services are therefore an attractive field both for research and for practical purposes. Sustainable planning of infrastructure development, spatial occupation and resource consumption requires a long-term perspective and an integrated approach to land-use management across Europe. Today, many datasets are made available through geospatial web services.

Interoperability is supported by the Open Geospatial Consortium (OGC) with a series of syntactic interface specifications, establishing protocols for the components exchanging geospatial information [1]. However, challenges remain in supporting the crucial tasks of discovery and retrieval of information sources that meet the user's needs. Metadata standards for the description of geodata exist as well as catalogue services to search them. But these do not account for the fact that the conceptualisations governing the different implementations have been constrained in different ways [2], causing semantic heterogeneity during discovery of information sources and retrieval of information [3].

In such open and heterogeneous environments, semantic interoperability is crucial for searching data sources and evaluating their content. What is lacking is semantic annotation of the information sources, i.e. a formal and explicit representation of their semantics [4], as well as a supportive environment for realizing semantic discovery and retrieval.

While the standardization efforts of the OGC concentrate on syntactic interoperability, the semantic web initiative has brought the semantic issues of information processing into perspective [5]. It seems promising to adopt the developments around the semantic web in order to approach semantic interoperability in geospatial web applications. Visions, architectures, and applications of this cross fertilization of geospatial and semantic web technology are cumulating in the notion of a *Geospatial Semantic Web* [6-9].

Semantic Web Services (SWS) represent the combination of two technologies: Semantic Web and Web services. They can be defined as “self-contained, self-describing, semantically marked-up software resources that can be published, discovered, composed and executed across the Web in a task driven automatic way” [10]. By using developments like the Web Service Modeling Ontology (WSMO) [11] and the Web Service Modeling Language (WSML) [12] for the semantic annotation of geospatial services, one could utilise SWS technology such as the Web Service Modeling Execution

Environment (WSMX)¹ to increase the efficiency and accuracy of discovering and integrating geospatial web services.

To describe a web service semantically, a comprehensive knowledge in logics, ontologies, metadata and various specification languages is required. Thus, two major impediments for realising the SWS vision in the area of geospatial services are:

1. the lack of web services that are semantically described, and
2. the lack of development tools that can hide the complexity of and automate the creation of the necessary semantic mark-up.

In this context, the *SWING* (Semantic Web services *IN*teroperability for Geospatial decision making) project² aims at deploying SWS technology in geospatial applications. In particular, it addresses two major obstacles that must be overcome for SWS technology to be generally adopted, i.e. to reduce the complexity of creating semantic descriptions and to increase the number of semantically described services. The project will develop methods and tools that can hide the complexity – and automate the creation – of the necessary semantic descriptions. *SWING* is aimed to provide an open, easy-to-use SWS framework of suitable ontologies and inference tools for annotation, discovery, composition, and invocation of geospatial web services.

The rest of this position paper is organized as follows. In Section 2 we give a short overview of core objectives of the project. Section 3 highlights the technical organization of the project, and Section 4 summarizes the expected impact of the project. Section 5 summarizes this position paper with an outlook on the future steps in the project.

2. Project Objectives

The core scientific and technological objectives of *SWING* are:

1. To develop an open, easy-to-use Semantic Web Service framework of suitable ontologies and inference tools for annotation, discovery, composition, and invocation of geospatial web services.
2. To evaluate the appropriateness of this framework by developing a geospatial decision-making application that can dynamically find and provide interoperable semantic web services.

Scientific and technological sub-goals to achieve the main objectives are:

- To capture the semantic requirements of geospatial services and geospatial decision-making application scenarios by developing relevant ontologies.
- To develop a tool for semantic annotation of geospatial web services based on semi-structured description, natural language texts and geospatial data.
- To adapt existing SWS technology (WSMO/WSML/WSMX) to provide a semantic discovery and execution tool to facilitate discovery and invocation of semantically described geospatial web services.
- To provide an open, easy-to-use development environment that hides the complexity and integrates the semantic annotation, the semantic discovery and execution tool.
- To innovate and integrate SWS technology in existing web catalogues for the purpose of enhancing the functionality and improving the hit-rate in service discovery.
- To develop a web-based geospatial decision-support prototype to evaluate the appropriateness of the proposed framework and to show dynamic service composition in practice. This prototype will have the potential of being further developed and turned into a management and assessment system for natural resources.

3. Technical Approach

SWING will develop a framework consisting of six components, which are depicted in Figure 1 below, and shortly highlighted in the following.

¹ <http://www.wsmx.org>

² <http://www.swing-project.org>

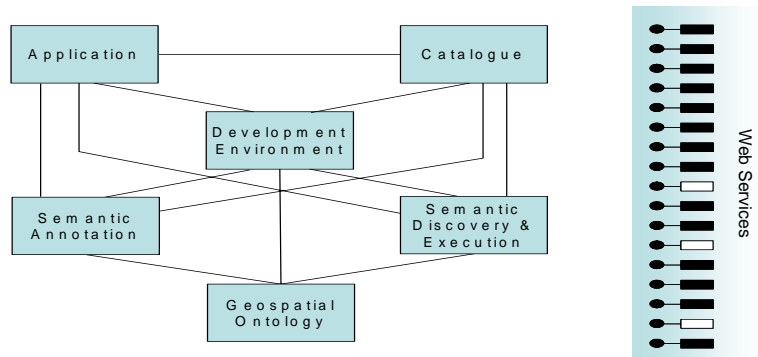


Fig. 1. SWING Framework Components.

The **Application** prototype will show dynamic discovery, composition and invocation of geospatial web services within the domain of sustainable exploitation of natural resources. Parts of the application prototype will be developed using the Development Environment. At run-time, the application prototype will utilise the Semantic Discovery and Execution component.

The **Semantic Discovery & Execution** component provides the basic Semantic Web Services infrastructure. It consists of a repository of semantically described web services and a set of inference tools for discovery and dynamic invocation of the services.

The **Geospatial Ontology** component contains a repository of ontologies used by the Semantic Annotation and the Semantic Discovery & Execution components. Ontologies provide formal definitions for concepts in a domain and the terms to denote them. Ontologies are increasingly used to uniformly access information. They can be applied for making the semantics of geospatial data sources explicit and enable automated semantic matchmaking. The ontologies are thus central both for semi-automatic annotation and for discovery and composition of geospatial web services within the domain of natural-resource decision-support tasks.

The **Semantic Annotation** component utilises information acquisition technology to analyse the semi-structured data descriptions of existing geospatial web services, in order to generate semantic annotations. These may be registered in the Semantic Discovery & Execution component in order to extend the number of semantically described web services.

The **Catalogue** provides a standard web service registry interface storing entries to classical geospatial and non-spatial services. In addition, it utilises the underlying components to provide semantically enhanced discovery functionality.

The **Development Environment** component is based on IBM's Open Source Eclipse Development Environment. It consists of a number of plug-ins that integrates and hides the complexity of the other components. Application and service developers can use the Development Environment to discover both semantic and non-semantic services, to semantically describe their services and to compose multiple services.

4. Expected Impact

The impact of the *SWING* framework will benefit several major user groups, i.e. geospatial decision makers, data and service providers, application developers and the research community. Geospatial decision makers will be able to use the dedicated application and hence decrease the time used to discover and utilise relevant data. Citizens are allowed to access the information from the decision making process and can thus better understand the rationale behind the decisions. Data and service providers will be able to use the catalogue component to annotate their services. Application developers will be able to use the development environment to create semantically annotated composed web services more effectively than before. The research community will be able to utilise the experience gained in the project and to directly experiment with, reuse or extend the core open source

components, i.e. the ontologies, annotation engine, execution environment and the development environment.

5. Summary and Conclusions

The ability to represent geospatial semantics is of great importance when building geospatial applications for the web. It will not only enhance discovery, retrieval and integration of geographic information, but it will also enable its reuse in other contexts than the original one. However, the scarcity of semantic annotation and the lack of a supportive environment for discovery and retrieval make it difficult to employ geospatial services to solve a specific task in geospatial decision making.

By deploying Semantic Web Service (SWS) technology in geospatial web applications, the SWING project aims at developing a comprehensive framework for semantically annotating geospatial services and for utilizing these annotations in service discovery, composition and invocation.

Major challenges of the work rely in identifying and solving differences between OGC and SWS paradigms, to account for the specific requirements of expressing geospatial semantics, to develop intelligent methods for (semi-) automatically annotating geospatial services and in developing a pilot application that will increase the use of distributed and heterogeneous services in geospatial decision making.

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