Proposing Metadata Elements for Web Processing Service (WPS) Profiles

Barbara Hofer
Department of
Geoinformatics – Z_GIS,
University of Salzburg,
Austria
barbara.hofer@sbg.ac.at

Abstract

Operations provided according to the current web processing service (WPS) specification are described based on their input and output parameters. This syntactic description of process parameters has been criticized for its generality. Descriptions that aim at going beyond this level of detail, need to include a description of the dependency between input and output; i.e. the transformation provided by the operation needs to be specified. Two groups of approaches have been proposed for providing such descriptions of operations: ontology-based approaches and WPS profiles. Ontology-based approaches formalize input, output, pre- and post-conditions of operations and allow automated discovery and composition of services. WPS profiles provide mostly textual descriptions of spatial operations on a conceptual, generic and implementation-related level. The assumption underlying this research is that there is a common set of elements for describing spatial operations that need to be contained in either of the two approaches. WPS profiles could therefore be structured according to elements of process ontologies, such that a linkage between WPS profiles and ontology-based approaches is eventually possible. The fostered role of WPS profiles in the recently published WPS 2.0 specification, may lead to an increased availability of WPS profiles that may serve as resource for establishing spatial operation ontologies.

Keywords: Online geoprocessing, WPS, WPS profiles, semantic service descriptions.

1 Introduction

Standardization has been introduced in the spatial domain to facilitate data integration and interoperation. While data providing standards such as web map services (WMS) and web feature services (WFS) are widely used, web processing services (WPS) are adopted on a slower pace [7]. Issues encountered with the WPS standard are among others related to its generality [5, 7]. The process description of a WPS provides name and format of input and output parameters, which does not specify the semantics of the parameters. Whereas the semantics of the output of a WMS or a WFS are specified [14], a client or user does not know beforehand which result a WPS will return. This circumstance increases the complexity of integrating WPS into client software and limits the use of WPS in practice. [2] suggested research on semantic descriptions of processing services together with research on orchestration and performance in their research agenda for advancing WPS.

One of the envisioned strengths of the service web is the automated discovery and composition of data and processing services [10]. Recent research foresees the meaningful application of operations, which demonstrates the importance of formalizing spatial data and operations on them [4, 18].

Proposals with different scope for the semantic description of WPS were made. We contrast ontology-based approaches and WPS profiles in this contribution. Work by [3, 6, 8] who dealt with search and discovery of geoprocessing services require the use of application and domain ontologies. The WPS specification 2.0, which has been published recently [13], enforces the idea of WPS profiles for more detailed specifications of the characteristics of a WPS. The proposal for hierarchical WPS profiles, that is extended in the specification, has been made by [12].

Ontology-based approaches have been criticized for being too demanding regarding necessary ontologies and annotations as well as for being too resource-intensive. The WPS profiles as foreseen in the WPS 2.0 specification provide a mostly textual description of operations, which limits the possibility to automatically consume the descriptions. We propose an analysis of the elements used in process ontologies to describe services. These elements are assumed to be contained in WPS profiles in a different encoding. A definition of key elements to describe services, may lead to structured metadata that can be used in WPS profiles. Basing WPS profiles on structured metadata may eventually provide the basis for filling operation ontologies.

2 The Challenge of Spatial Operation Descriptions

The WPS specification foresees three interfaces [17]: *GetCapabilties*, *DescribeProcess*, and *Execute*. *GetCapabilities* lists operations provided by a server and how to access these. *DescribeProcess* lists input and output parameters for operations to prepare *Execute* requests to retrieve results from a server. The description of operations in a *DescribeProcess* response includes a title and abstract of the operation and identifier, title and format of the operation's input and output parameters. For instance, a buffer operation may require *input_data* in GML format. Value ranges or data types are not specified in the WPS 1.0 specification, which is about to change with the WPS 2.0 specification [13].

A contribution to the semantic description of web services is the best practices document published by the OGC [14]. Semantic annotations link service metadata and terms used therein to domain ontologies or thesauri that specify the meaning of the given terms. This allows, for example, considering the meaning of data during service discovery. The OGC best practices document details annotations on three different levels (service metadata, data model, data) and discusses their use predominantly for data provision services [14]. Work on semantic annotations of WPS has been done in the ENVISION project [11]. The annotation of WPS in this project focused on annotating terms in response documents to service requests and the elements that are foreseen in the WPS DescribeProcess documents.

The challenge of an extended description of geospatial operations provided as WPS is that stating input and output of operations is not sufficient. The relationship between input and output elements has to be described as well [14]. Stating input and output of operations provides their syntactic signature. Different operations can have the same syntactic signature as well as differing signatures to access the same functionality [8]. Restricting service descriptions to input and output specifications becomes an obstacle when reuse and composition of WPS are requested as it reduces recall and precision in service discovery [8, 14]. The description of an operation, therefore, needs to consider the transformation of input into output triggered by the operation.

A comprehensive ontology of spatial operations that represents the link between input and output parameters does not yet exist outside software packages and textbooks. Reports on search and discovery solutions as well as composition of services based on ontologies generally state that the data and process ontologies used are not fully established [3, 8, 9]. The GeoSPARQL ontology, which covers query functions for simple features and region connection calculus, as not been evaluated for this purpose yet [15]. The lack of ontologies of spatial operations is one limitation of the wide application of ontology-based approaches.

The WPS 2.0 specification contains a revised proposal for WPS profiles [13]. These profiles, which are linking a service to resources describing the concept and requirements of an operation, may provide a resource for establishing process ontologies in the long run. The next section details WPS profiles and existing ontology-based approaches with the objective to highlight correspondence between these approaches.

3 Approaches for Describing WPS Operations

Ontology-based approaches and WPS profiles both address the issues of capturing input and output of operations as well as their dependencies. This research assumes that both approaches are essentially different encodings of the same elements that are required to describe spatial operations in web services.

3.1 Semantic WPS Descriptions

Several ontologies for modelling web services were developed by the Semantic Web community: e.g., the web service modelling language (WSMO) and a web service ontology based on the web ontology language (OWL-S). Additionally, the Provenance Ontology PROV-O is a recommendation of the World Wide Web Consortium (W3C) for describing provenance of web services that also strongly relates to the operations applied to input data.

The ontologies mentioned provide a structure (together with a formalism and a reasoner) for describing services. An operation description based on the capabilities of web services in WSMO, for example, requires the specification of [16]:

- NonFunctionalProperties
- SharedVariables
- Precondition
- Postcondition
- Assumption
- Effect.

NonFunctionalProperties refer to service owner, accuracy, etc. *SharedVariables* are variables used in the specification of *Pre-* and *Postconditions*. *Pre-* and *postconditions* define which information a service needs for execution and what a service returns. *Assumption* and *Effect* of web services relate to states in real world, which is not required for information providing WPS [8].

The structure of web service ontologies has been applied in several works on semantic search, discovery and composition of spatial web services. [3, 6, 8, 10]. The elements of the general web service ontologies are slightly adapted to the properties of spatial operations provided as services as mentioned above [3, 8]. The approaches differ in the logics used for formalizing the inputs and outputs respectively pre- and postconditions of operations. Lutz [8], for example, uses two ontologies: one ontology based on descriptions logics (DL) for describing input and output, whereas the pre- and postconditions of operations are stated in first order logics (FOL) as their evaluation is not possible in DL.

An example of the specification of an operation given in [3] is the operation *intersection*. The functional description of the intersection web service specifies as precondition the input of two polygons with the same spatial reference system and as output a polygon representing the intersection of the inputs.

The general structure of web service descriptions suggested in web service ontologies seems to be applicable for spatial web services as for general web services. The level of detail on which operations are specified in an ontology varies for the different approaches. [8] specifies the functionality of services in great detail, whereas [9] remains more on a conceptual level of description.

The research on discovery and composition of spatial processes is directed towards identifying formalisms for improving the tasks as hand. The establishment of comprehensive ontologies is not in the foreground and a limiting factor for the application of the approaches.

3.2 WPS Profiles

Müller [12] introduces a hierarchical structure of service profiles that is part of the WPS 2.0 interface specification [13]. The draft WPS 2.0 specification lists the following three

profiles: concept profile, generic profile, and implementation profile. Looking at an example of a buffer operation provided in the specification [13], the concept profile specifies what a buffer operation does on a conceptual level. The abstract specification focuses specifically on buffer operations on simple features, stating the mechanics of the operations and signatures for input and output. The implementation profile adds data exchange formats to the description.

A profile registry is foreseen that contains the profiles. Metadata tags in the *DescribeProcess* response will provide links to the WPS profiles.

In its current form, the proposal of hierarchical process profiles does not link to the OGC best practices on semantic annotations. In addition, [12] argues against ontology-based approaches that show correspondence to generic process profiles. His arguments are that the required operation and data type ontologies are not fully established and that these approaches are slow when executing reasoning. However, [12] does request registries of abstract data types in standardized form to achieve machine-readable generic profiles.

4 Metadata Elements for WPS Profiles

Metadata have been proposed as approach to capture the details regarding spatial operations of WPS services [1, 12]. However, the required sets of metadata for spatial services are not yet readily defined [9]. This contribution suggests that metadata elements for operation descriptions in WPS generic profiles can be based on elements of process ontologies. Essentially, the service description in a process ontology is separated in *precondition*, *postcondition* and *sharedVariables* [3]. These elements state the input and output of an operation and how these are related.

The application of the structure of process ontologies to the example of a WPS generic profile of a buffer operation [13] looks as follows:

Precondition: geometric object with name and spatial reference system; distance parameter with name and data type.

Postcondition: geometric object with name and same spatial reference system as the input geometric object, containing points around the geometric input object less than or equal to the specified distance.

SharedVariables: input geometric object, distance parameter, spatial reference system.

This structure is a first step to increase the specification of elements required in WPS generic profiles, which are proposed as running text descriptions. However, the descriptions of the elements are still informal and need to be complemented with a registry of abstract data types and related concepts [12]. A further specification of terms would provide a similar level of specification as in libraries of programming languages, where data types are defined for reference. Further work will show how the level of detail of operation specifications can be increased and which vocabulary is required to develop tools for filling the structured descriptions of WPS generic profiles.

Acknowledgements

Thanks to reviewers of the abstract for their valuable comments. This contribution was supported by the Technical University of Dresden, Germany with a DRESDEN Junior Fellowship.

References

[1] Anselin L. From SpaceStat to CyberGIS: Twenty Years of Spatial Data Analysis Software. *International Regional Science Review*. 35(2): 131-157, 2012.

[2] Brauner J., Foerster T., Schaeffer B. and Baranski B. Towards a Research Agenda for Geoprocessing Services. In: Haunert J, Kieler B and Milde J, eds. *12th AGILE International Conference on Geographic Information Science*, Leibniz University Hannover, Germany, 2009.

[3] Fitzner D., Hoffmann J. and Klien E. Functional description of geoprocessing services as conjunctive datalog queries. *Geoinformatica*. 15(1): 191-221, 2011.

[4] Härtwig M., Müller M. and Bernard L. A Generic Web Service for Ad-hoc Statistical Spatio-Temporal Aggregation. *Transactions in GIS*. 18(4): 527-543, 2014.

[5] Jones R., Cornford D. and Bastin L. UncertWeb Processing Service: Making Models Easier to Access on the Web. *Transactions in GIS*. 16(6): 921-939, 2012.

[6] Lemmens R., Granell C., Wytzisk A., de By R., Gould M. and van Oosterom P. Integrating Semantic and Syntactic Descriptions to Chain Geographic Services. *Internet Computing, IEEE*. 10(5): 42-52, 2006.

[7] Lopez-Pellicer F. J., Rentería-Agualimpia W., Béjar R., Muro-Medrano P. R. and Zarazaga-Soria F. J. Availability of the OGC geoprocessing standard: March 2011 reality check. *Computers & Geosciences*. 47(0): 13-19, 2012.

[8] Lutz M. Ontology-Based descriptions for semantic discovery and composition of geoprocessing services. *Geoinformatica*. 11(1): 1-36, 2007.

[9] Lutz M. and Kolas D. Rule-based discovery in spatial data infrastructure. *Transactions in GIS*. 11(3): 317-336, 2007.

[10] Lutz M., Lucchi R., Friis-Christensen A. and Ostländer N. A rule-based description framework for the composition of geographic information services. *Proceedings of the 2nd international conference on GeoSpatial semantics*. Springer-Verlag, Mexico City, Mexico:114-127, 2007.

[11] Mladenić D., Moraru A., Škrjanc M., Rihtar M., Grčar M., Roth M., Maué P., Michels H. and Llaves A. Model annotation component and guidelines. ENVISION (Environmental Services Infrastructure with Ontologies) Project, Project No: 249120, 2011.

[12] Müller M. Hierarchical process profiles for interoperable geoprocessing functions. In: Vandenbroucke D, Bucher B and Crompvoets J, eds. *Proceedings of the 16th AGILE Conference on Geographic Information Science*, Leuven, Belgium, 2013.

[13] Müller M. and Pross B. OGC WPS 2.0 Interface Standard. OGC, http://docs.opengeospatial.org/is/14-065/14-065.html, 2015.

[14] OGC. Semantic Annotations in OGC Standards. *OGC Best Practices*. Open Geospatial Consortium:59, 2012.

[15] Perry M. and Herring J. OGC GeoSPARQL - A Geographic Query Language for RDF Data. OGC, http://www.opengeospatial.org/standards/geosparql:75, 2012.

[16] Roman D., Keller U., Lausen H., de Bruijn J., Lara R., Stollberg M., Polleres A., Feier C., Bussler C. and Fensel D. Web Service Modeling Ontology. *Applied Ontology*. 1(1): 77-106, 2005.

[17] Schut P. OpenGIS Web Processing Service. OGC Publicly Available Standard:pp.73, 2007.

[18] Stasch C., Scheider S., Pebesma E. and Kuhn W. Meaningful spatial prediction and aggregation. *Enviornmental Modelling and Software*. 51: 149-165, 2014.