Interoperable Processing of Sensor Data in SDIs – A Use Case for Wind Power Analysis

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Abstract. Nowadays, sensor data are omnipresent and ubiquitous available. Additionally, sensor measurements were required in several domains such as disaster management or renewable energies. This paper presents a proposal how sensor data measurements can be integrated in a standardized Spatial Data Infrastructures (SDIs). Therefore we extended the SDI by the OGC Web Processing Service (WPS) in order to compute and access sensor data measurements served by a Sensor Observation Service (SOS).

Keywords: SDI, Sensor, SOS, WPS, WPS Profile, Renewable Energy

1 Introduction

Classical *Geographic Information Systems* (GIS) support geospatial analysis and generating complex workflows in a proprietary manner. However, each system interprets each geospatial analysis in a specific way without clarifying a formal definition of the analysis. This hinders to interact, exchange or execute analysis automatically on different systems. For the sake of interoperability, a formal definition of geospatial analysis is required to obtain proper working distributed systems. The formal definition needs to be stated in both syntactically and semantically way. Regarding the movement towards Web services, *Spatial Data Infrastructures* (SDI) are being established on regional, national and supranational level e.g. GDI.de or the European INSPIRE initiative. Especially, regarding the establishment of SDI's, interoperability of analysis is required to ensure further utilization of geospatial data hold by web services. Thus, it is necessary to identify methods to describe and structure the main *Geographic Information Analysis* (GI-Analysis) formally of one specific domain.

On the one hand, the GI-Analysis of one domain needs to be identified. On the other hand, each analysis has to be reviewed in regard to its internal structure. On each level, GI-Analysis need to be described formally keeping relevant attributes and parameters in mind. Identifying methods to formally describe a GI-Analysis is one essential topic of this work. For that, this work

is to be located on the conceptual level leading to conclusions that help to develop standards ensuring and enabling interoperability of GI Analysis.

2 How to build a WPS Profile

Talking about GI-Analysis the OGC Specification *Web Processing Service* 1.0 [1] may be considered as the interface to enable interoperable GI-Analysis in a SDI. In a nutshell, a WPS offers the possibility to hold a repository of implemented geospatial processes. A client may request a description of the repository (*GetCapabilities* operation) respectively a detailed description of each process (*DescribeProcess* operation). Finally, it is possible to execute each process (*Execute* operation). The process description (*DescribeProcess* Response) is the essential aspect required to execute spatial analysis. As the WPS is a generic interface, the process description defines the structure of an analysis through description of the input-data and the output-data. However, as the WPS was designed to be a generic interface, no specific GI-Analyses are defined and though, no specific standardized GI-Analysis are offered via this interface. Therefore, the specification offers the option to define WPS-Profiles. In principle a WPS Application Profiles includes the formal description of one specific process and an OGC URN that identifies the analysis. The specification further states that it is possible to specify a repository that represent a semantically structure of processes which may be part of the same application domain [1].

Although there are quite a lot of scientific papers that show how geospatial analysis can be provided through the WPS interface [2, 3, 4, 5, 6] several authors believe that the essential goal, to enable interoperability, has not been reached yet [7]. This is reasoned by the strong generic nature of the specification and by the imprecise process description. Especially in regard to the semantic description of GI-Analysis several authors see the need for further research [8, 5, 9].

Concerning application domains, there are some examples on how to build a semantically structure in a WPS Profile [7, 10, 6]. However, as the process description is regarded not to be sufficient, the definition WPS Profiles is hindered since the description is an essential aspect of a profile. Although there are several approaches in building classification schemes for GI-Analysis [11, 12, 13, 14], those are too general or too generic to enable the development of domain-specific interoperable GI-Analysis so further research regarding this topic is required.

In a nutshell, there is further need for research concerning interoperability of GI-Analysis. To even broaden the view on WPS Profile, this paper is on integrating live sensor data in a WPS Profile since the link between sensor and analysis is an important area of application.

3 Integrating Live Sensor Data in 3D SDI

The OGC *Sensor Web Enablement* (SWE) initiative dealing with the integration of all kind of types of dynamic sensor data like wind measurements, temperatures, water levels etc. in a standardized way within SDIs [15].

3.1 State of the Art

The integration of sensor data into a SDI was recognized with the emergence of a variety of live sensor data sources coupled with rapidly declining sensor costs [16]. However, the collecting of sensor data can cause huge data sets. The question that arises is: how can this massive datasets are analyzed in a standardized way. One solution to support utilization of these datasets is the use of geospatial analysis offered via the WPS interface. First steps are made providing traffic data (TMC data) by a *Sensor Observation Service* (SOS) [17] and processing of the SOS results using a WPS [18]. In another use case we analyze the dispersion of a gas plume caused by a gas leakage and integrate wind speed and wind direction measurements form a SOS in our 3D SDI [19].

3.2 Use Case - Workflows for Renewable Energies

Our research focuses on the integration of live sensor data of the renewable energy domain into SDI. Based on former research [18, 19], initial steps have been taken by the integration of live sensors in our 3D WPS. Therefore, as a proof of concept, we present a proposal how the integration of SOS-based wind measurements in a SDI could take place via WPS profile.

In our geoprocessing workflow, the WPS process `WindPowerStationScenario3D´ uses input data from a SOS interface to encapsulate weather data like wind speed and wind direction provided for example by the German Weather Service (DWD). The input parameter of the WPS process is the location of the weather measuring station (x, y, z coordinates), and the actual measurements of wind speed and direction. Thus, the `WindPowerStationScenario3D´ process sends a *GetObservation* request to the SOS. The next step is the interpolation of wind speed and direction measurement of each weather station by the WPS interpolation process. The interpolation takes place based on the SOS values of the weather measurement stations.

A location analysis for the use of wind energy requires the consideration of specific wind conditions. Generally a wind turbine or a wind park is economically profitable with wind speed of at least 6 m/s at hub height. Besides wind speed there are further limiting factors for the usage of wind

energy and the appropriate location. This includes protected areas and nature reserve, the slope of terrain, a buffer around settlements, the infrastructure, and water or forest surfaces.

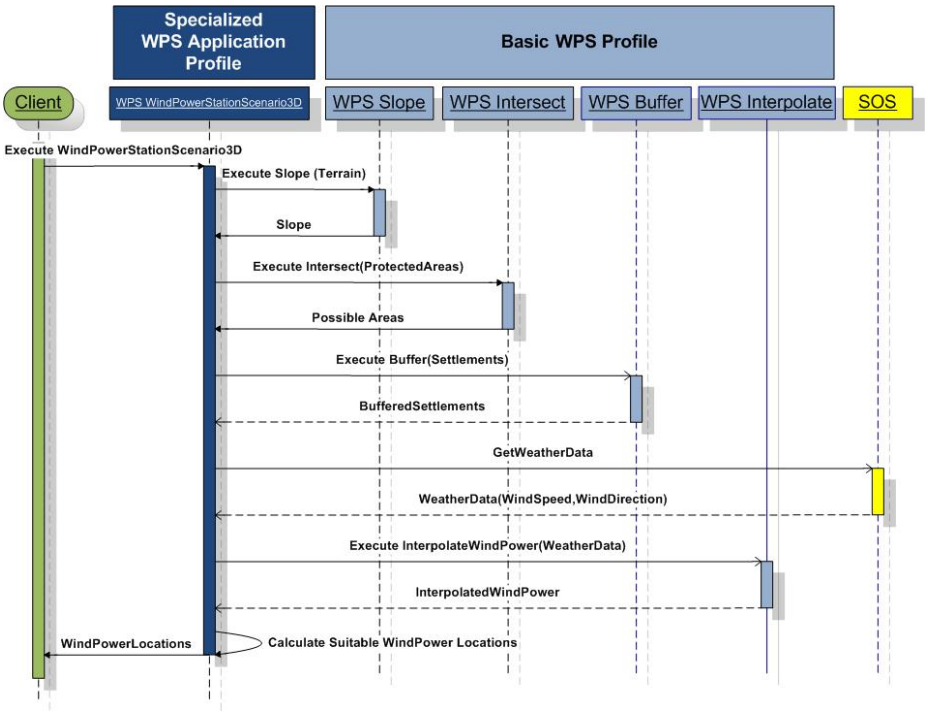

Fig. 1. Sequence diagram overview WPS Application Profile for `WindPowerStationScenario3D´ analysis

3.3 Proposal for a `WindPowerStationScenario3D´ WPS Application Profile

Currently, there is no formal specification about the combination of application profiles and the OGC SOS. In a nutshell the SOS allows operations to request live sensor data respectively sensor data from a specified time period. In respect to a WPS Application Profile, a detailed description of the required sensors is an essential prerequisite on building WPS Profile that integrates live sensor data. Technically the SOS provides the option to formally describe one specific sensor. This description should be added to a WPS Application Profile. One possible solution is to extend a WPS Profile by the description of the depending data sources. Whereby, the data source must be described in terms of their data structure. This way, the definition of an analysis would be more precise since the definition of input data is essential for the correct outcome of the process.

In order to operate a wind park economically, the possible energy potential must be determined for planning the location of a wind park. For this a domain specific WPS Application Profiles `WindPowerStationScenario3D´ was developed. Therefore, we use generic basic analysis like the buffer or the slope calculations of a terrain model and integrate these basic analyses in a complex workflow. Thus, suitable locations for wind parks can be determined. Still missing is the integration of the weather measurement data. This is made by the definition of a WPS extension for live weather measurement sensors. Based on the measured weather data the wind speed and the wind direction for different hub heights can be computed. For this computation models already exist. But to access these models in an interoperable and standardized way it may be available via the WPS interface.

4 Summary and Outlook

In this paper we present first steps how sensor data can be integrated in SDI through a WPS. This takes place by a WPS Application Profile based on a typically use case for wind power analysis in the renewable energy domain. Further research has to deal with the integration of more complex wind speed simulation models based on *Computational Fluid Dynamics* (CFD). Additionally we would like to integrate our results into our 3D SDI.

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