Towards a Spatiotemporal Aggregation Service in the Sensor Web

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ABSTRACT

Observations published in the Sensor Web differ in the temporal or spatial extent which is observed as well as in the resolution the data is available. In this paper, we present a profile of the Web Processing Service for the spatiotemporal aggregation of observations in the Sensor Web.

INTRODUCTION

A growing amount of observations from different applications such as long-term environmental monitoring or disaster management is published in the Sensor Web. However, as the observations differ in the spatiotemporal extent covered by them and their resolution, aggregation of observations in space and time is needed. A common approach for a web-based spatiotemporal aggregation is currently missing. The main contribution of this work is the definition of a Spatiotemporal Aggregation Service (STAS) in the Sensor Web using standardized web-based geoprocessing.

WEB-BASED SPATIOTEMPORAL AGGREGATION

The STAS provides basic spatiotemporal aggregation methods known from the database community as described in (Vega Lopez et. al., 2005). Datasets are passed by reference to the STAS and the STAS publishes the aggregated observations to data services as well. In our exemplary scenario (Figure 1), the STAS computes the daily maximum temperature measured at weather stations and aggregates these values to mean values of administrative areas.
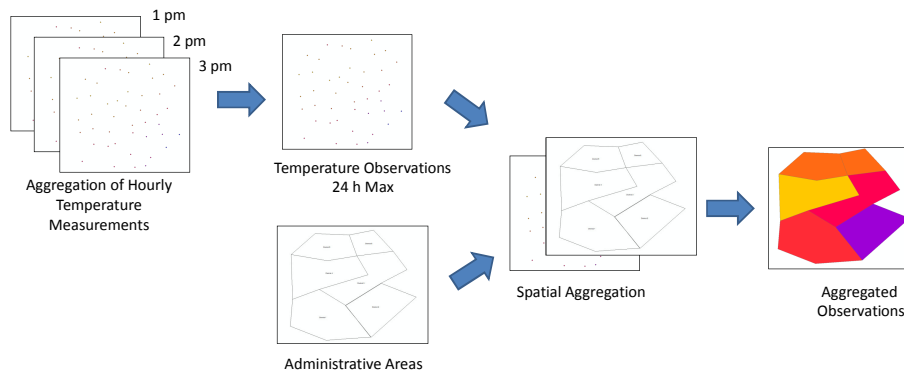

Figure 1: Exemplary Aggregation Workflow executed by the STAS

The STAS is defined as a profile of the Web Processing Service (WPS) (Schut, 2007), an established standard for providing web-based geoprocessing. The standard is generic to be used for different geoprocessing functionality ranging from basic GIS operators as described in (Brauner, 2008) up to the provision of complex environmental models (Granell et. al., 2010). To ensure interoperability between different applications, profiles restricting the generic standard are needed (Kiehle&Foerster, 2010). Hence, we develop the STAS as a WPS profile defining an observation aggregation process. The spatial and temporal aggregation methods (e.g. MIN, MAX, MEAN) are passed as parameters of this process. Depending on whether one, e.g. only the spatial aggregation method, or both parameters are set as process parameters, the observations are aggregated in space and/or time. An additional process parameter indicates whether the spatial aggregation should be done first or not (default).
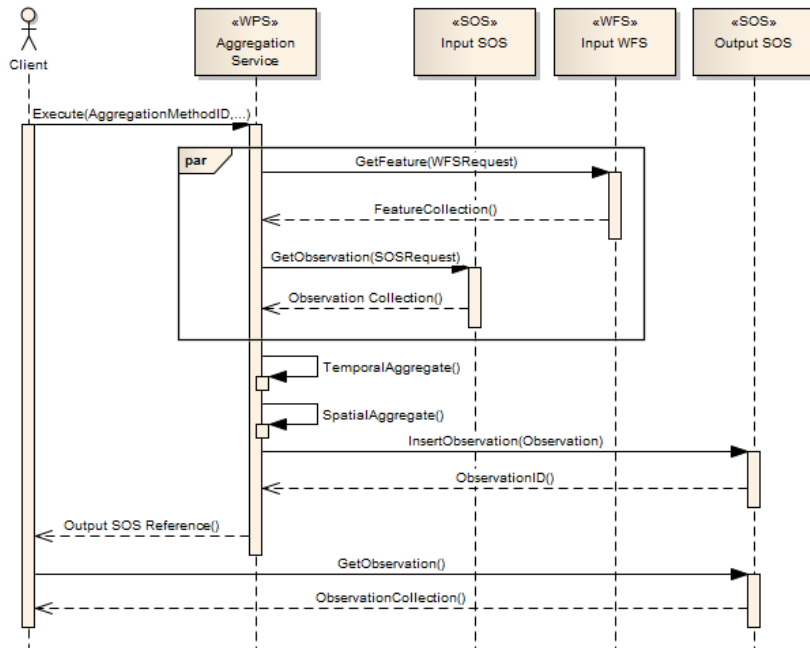

Figure 2: UML sequence diagram of the aggregation workflow executed by the STAS

Figure 2 shows the workflow of the aggregation process within the STAS. The aggregation process automatically retrieves the original observations from a Sensor Observation Service (SOS), the standard interface for retrieving observations in the Sensor Web (Na&Priest, 2007). In case of spatial aggregation, the geometries with which the observations are aggregated spatially are queried from a Web Feature Service (WFS) in parallel. References and requests to the services have to be passed by the clients. Based on the requested temporal resolution, the observations are then aggregated temporally. Afterwards, observations are aggregated spatially. Finally, the aggregated observations are inserted into a transactional SOS to become accessible in the same interoperable way as the source data.

IMPLEMENTATION

We have implemented the STAS based upon the 52°North WPS framework as open source. The deployment in the described scenario has shown that the STAS can be configured to perform spatiotemporal aggregation of observations. However, we consider the work in its current state as a starting point. Currently, only simple aggregation operators are advertised by the STAS. We will extend the STAS by providing more complex aggregation methods such as methods considering the spatiotemporal variability and assign weights when aggregating the observation values.

DISCUSSION

The STAS as a WPS profile allows for a flexible reuse of the aggregation processes and for a provision of the aggregated observations in other SOSs. However, in the case of large datasets a drawback might be the communication overhead when the data has to be transferred between the SOSs and the STAS. In that case, it might be better to tightly couple the aggregation process to the SOS providing the large observation sets. Thus, another possible approach would be to extend the GetObservation operation to provide aggregation functionality. The STAS might be used in the backend of the SOS to provide the functionality. Efficient caching strategies might also be considered to deal with large datasets.

Spatial aggregation is currently done by passing vector geometries to the STAS. As aggregation of point measurements to grid cells is also a common use case, we plan to extend our approach to also support coverage data. Furthermore, a rescaling of coverages from a fine to a coarser resolution might be included as well.

The provenance of observations is currently modeled as a metadata property of the aggregated observations. While this works well for just one aggregation step, it has to be explored how the provenance can be described in chains of observation aggregation processes. Related to chaining of observation aggregation processes, we will explore how a WPS-T as proposed by Schaeffer (Schaeffer, 2008) can be used to build complex aggregation methods with the STAS.

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