Marine Modeling as a Service

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Abstract. Modeling marine environments is a necessity to provide basic knowledge for decision making in coastal zone management. Current modeling software is usually implemented as stand-alone solutions. With the trend towards data infrastructures, efforts need to be made to introduce marine modeling into such infrastructures on an interoperable basis in order to improve its capabilities. We propose a service architecture, relying on trusted OGC services like the Web Processing Service or the Sensor Observation Service. We briefly summarize an implementation strategy.

Keywords: Spatial Data Infrastructures, SWE, WPS, Marine Data Modeling

Motivation

One of the main tasks of the Federal Waterways Engineering and Research Institute, Coastal Division in Hamburg, is the modeling of estuary systems adjacent to the North and Baltic Sea in order to scientifically study the effects of human activities on the physical processes and parameters. Hindcast and forecast modeling with elaborate analyses are used to quantify the characteristics of short and long term impacts of weather, climate and tides on coastal areas. Natural tidal rivers and coastal waters are being altered to an ever increasing extent in order to meet the requirements of ocean-going vessels, coastal protection and water management. Hydraulic engineering projects affect water levels, currents, storm surges, and, above all, sediment transports by dredging or impounding measures of rivers and the coastal areas. An example is the constant monitoring of the Jade River and its estuary, where sediment movements are crucial for the Jade-Weser-Port, which is currently being built.

These interventions come with possible detriments for the environment and potentially increasing maintenance costs. Consequently, impact assessment studies of these projects with numerical simulation models are an indispensable basis for political decision makers, regional waterways and shipping administrations as well as port authorities. Currently these simulations are carried out by highly specific modeling software that is tailored to the task and of a stand-alone nature. In times where Spatial Data Infrastructures (SDI) are not only the state-of–the-art of interoperable data distribution but are also enforced by super-national treaties, such proprietary systems, output formats and non-standardized interfaces are a major hindrance of making the results of modeling widely available. Software dependent formats hinder reusing the results in other software systems, which includes reproducing scientific results of a high public interest like sea level rise scenarios. But even if formats are syntactically homogenous, reusability and comparability is further constrained by different geometries and time steps during processing. Where time and space parameters are not running synchronously, linking models requires some effort. Further, there is the question how data exchange during run-time is handled, for example, if a hydraulic model should be supplied with results of a rainfall runoff model.

Standardization for model interfaces to face the issues is an ongoing task, although large modeling frameworks like UnTRIM [1] or MARINA[2] are not standardized yet. However, there are approaches aiming for solutions, for example CSCM [3] or the OpenMI Association [4], which works on interfaces to standardize model engines from the hydrological domain to overcome the issues of different formats, geometries and time steps.

While the OpenMI standard focuses on connecting models directly, publishing modeling software over standardized web services enables the combination with other web services and therefore data. The introduction of such a service into a SDI creates possibilities for intersecting model results with other spatial data [5], possibly even most recent data from sensor networks.It also enlarges the possible user group and visualization possibilities through the inclusion in geoportals. It has further the advantage of bypassing another major issue of large-scale numerical models: the often massive requirements of computing power and memory, which are usually not available on desktop PCs, can be outsourced and used from arbitrary providers.

Hence, efforts have to be made to migrate these isolated modeling applications into a service infrastructure. In the following, we propose an architecture for this and show how we plan an implementation as part of the Marine Data Infrastructure Germany project (MDI-DE) [6].

Architecture

To lift marine modeling into a service infrastructure, the modeling software has to be wrapped with a communication interface, where the web standards certified by the Open Geospatial Consortium (OGC) enable widely recognized interoperability. The appropriate OGC specification for our purpose is the very adaptable Web Processing Service (WPS) [7]. Once a modeling software is wrapped inside a WPS, the modeling algorithms need to be provided with raw data and parameters on which the simulation is based. To perform these tasks, the Sensor Web Enablement initiative of the OGC [8] offers appropriate standardized services, for example the Sensor Observation Service (SOS) [9]. Once started, the modeling process can access data from either live sensors or databases connected to the SOS. The advantage of using an SOS as an additional layer instead of coupling the WPS directly with a database is the possibility of including live sensor data into the software model thus providing the simulation with the most recent data available and join or compare it with archived data, as Fig.

depicted in figure 1. However, there is still an interoperability gap between data and service providers. While services are well standardized, the connection towards the sensor outputs is lacking specification. Approaches have been made to consider using a transactional SOS [10], a sensor bus [11] or Sensor Interface Descriptors [12] to enhance the communication between sensor outputs and services. Although, this issue is outside the scope of this work, it should be considered in consecutive research to reach full interoperability and simplify the integration of further parameters and data.

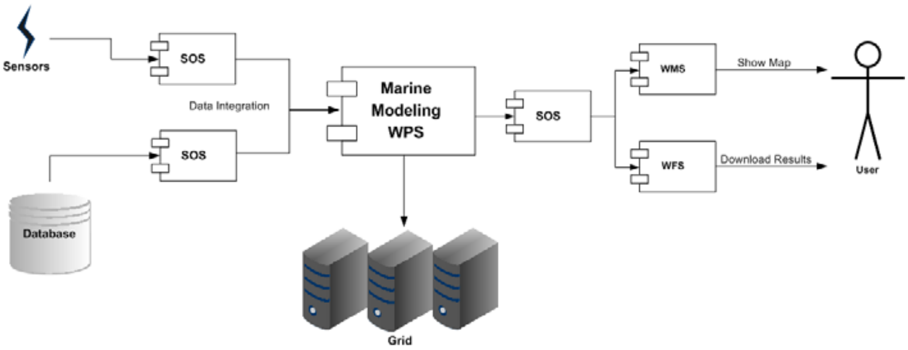

Fig. 1. The proposed architecture for coupling of SOS and WPS in a SDI

Since modeling processes are elaborate and complex and data becomes very voluminous, a single server can quickly reach its limits. Hence, these processes are usually run on a cluster or a grid. Unfortunately, connecting WPS and grid computing poses a set of problems, which have not yet been fully solved, although several works addressing these issues have been made [13][14]. Using a grid might help to ease the problem of the resource hunger of numerical modeling, but it has to be assumed that calculations of larger tasks might take a long time. Computing the morphodynamic of the North Sea might take up to weeks even on a supercomputer. As those response times will not allow to show calculated results in GIS or WPS clients without timeouts even for relatively small computed areas, we intend to exploit the ability for asynchronous processing slated for the WPS 2.0 Specification. The user should then be able to send a request to the WPS and receive a processing-accepted response from the server. The WPS executes the modeling process and stores the result on a web server. Upon completion, the user receives a message with a link to the download location of the processing results. A second option would be the presentation of the multidimensional data by a Web Map Service (WMS) [15] as a map of selected parameters at a given time. By styling those according to Styled Layer Descriptor (SLD) rules [16], a WMS can be used to provide easy to read maps. For more advanced users, the results also need be available in re-usable format, which can be provided by a download service like the Web Feature Service (WFS) [17].

An alternative – and often more relevant – way to view the resulting data is to concentrate on the variation of parameters at one spatial position throughout time. In order to provide the data in a form suitable to create timeline diagrams, we again intend to make use of the SOS. During the modeling process, space and time are discretized, space is fitted onto an (usually) irregular grid and time into discreet steps.

By defining the vertices of the grid as individual sensors and the timesteps as the intervals in which the sensor provides date, we can utilize the SOS for the transportation of our results.

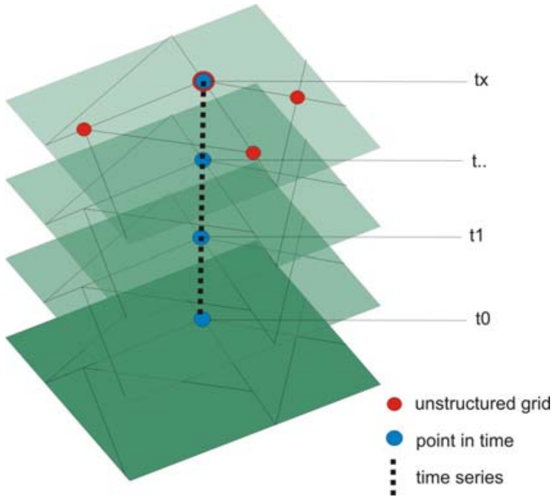

Fig. 2. Defining Grid Vertices as Sensors

Implementation Strategy

We intend to establish a working prototype within the time frame of the AufMod Project, which is due to end in winter 2012. AufMod [18] (*Model-based analysis of long-term morphodynamic processes in the German Bight*) aims at defining and analyzing sediment transport volumes based on different numerical simulation models, providing a large test bed for integrating sensor services. Along with the proposed framework, results of the project will be made available in the MDI-DE.

It is planned to implement the proposed architecture shown in figure 1. Sensors and databases will be accessed via an SOS adapter to the SOS, where SOS4R[1] would be a suitable solution. To wrap the modeling software within a WPS, formats, input and output parameters have to be introduced to the WPS. Aiming for a fast and easy way to accomplish this, we intend to use the free zoo project[2] framework. This open source project is capable of coupling the WPS wrapper and the software to be wrapped via an easily adjustable configuration file. Nevertheless, a configuration still requires adequate knowledge of the WPS interface and the applied modeling software. Further developments on this issue are planned during the ongoing project. While we expect to profit from ongoing research for approaching a grid via a WPS, a single server will

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[1] http://www.nordholmen.net/sos4r/
[2] http://zoo-project.org

be sufficient for early testing purposes. The open source paradigm will further govern choices for technical solutions.

Finally, the use of the open source software GeoServer[3] is intended as visualization and download service component as it encases both functionalities in a single, easy to set up software.

Summary

Basic technology for this venture has already been developed and standardized, often as ready to use open source projects. The difficulties to be faced, like the interoperability gap between sensor output and servers or the combination of grid computing software and a WPS, have been identified and need further exploration. During the runtime of the MDI-DE project we plan to implement the presented concept. Among other scientific tasks, this will improve the accessibility of marine models and modeling results, thus making them available for other applications and addressing additional potential user groups.

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[3] http://geoserver.org

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