GENESIS Employing Web Processing Services and Sensor Web Technology for Environmental Management

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INTRODUCTION

The GENESIS project aims at providing an efficient Web-based software solution for environmental management and health risk related services in Europe. The motivation for the work is to provide an extensive set of software components that facilitate the rapid deployment of complex distributed information systems where a wide variety of data sources are subject to an even wider variety of processing steps to obtain ready to use information products.

The GENESIS software solution is validated on a number of real-life pilot applications. Inside the GENESIS project, it is put to practice within multiple pilots in both the Water and Air Quality thematic domains. In addition, GENESIS technology was employed inside the GEOSS Architecture Implementation Pilot Phase III initiative.

The following sections will firstly introduce the overall GENESIS software solution and then zoom in on the most relevant GENESIS software components. Subsequently the use of the technology within the pilots is discussed.

THE GENESIS SOFTWARE SOLUTION

The GENESIS software solution depicted in Figure 1, based on a Service Oriented Architecture (SOA), is composed of a set of secured, standardised Web Services and customisable Web Service Clients that can be easily deployed in a Web Portal. The Web Services that are made available cover the full chain from discovery of data and services to the exploitation of processing results. Within the GENESIS SOA, these services are deployed using the SOAP protocol (Gudgin et al., 2007) to enable service orchestration and a common authentication and authorisation mechanism.

The GENESIS project has adopted the Open Geospatial Consortium (OGC) Web Processing Service (WPS, Schut 2007) Standard as the Web Service interface specification for the various distributed processing applications. They are activated via an intermediate workflow controller from a set of WPS client portlets. The workflow engine allows a flexible orchestration of multiple Web Services and the resulting composite service is itself exposed as a WPS instance.

The most relevant components here are introduced in the following sections.

GENESIS Web Portal

The GENESIS Web Portal proposes user interfaces to interact with various GENESIS web services (Orchestration services, Discovery services, Processing services, Fusion services …). The Portal is components based, allowing a simple integration of additional web user interface components compliant with the JSR 286 portlet specification (Figure 2). The Web Portal comes with a number of templates that allow to easily instantiate specific Web-based Graphical User Interfaces (portlets) to

interact with remote web services based on standard interfaces such as various types of OGC Catalogues Services (ISO AP Profile, ebRIM CIM, Sensor, EOP, ...) and various OGC data services as described below (Voges and Senkler 2007; Lesage 2007; Houbie et al. 2010; Primavera 2008). An instance of the GENESIS Portal is accessible at http://gppf.genesis-fp7.eu/.

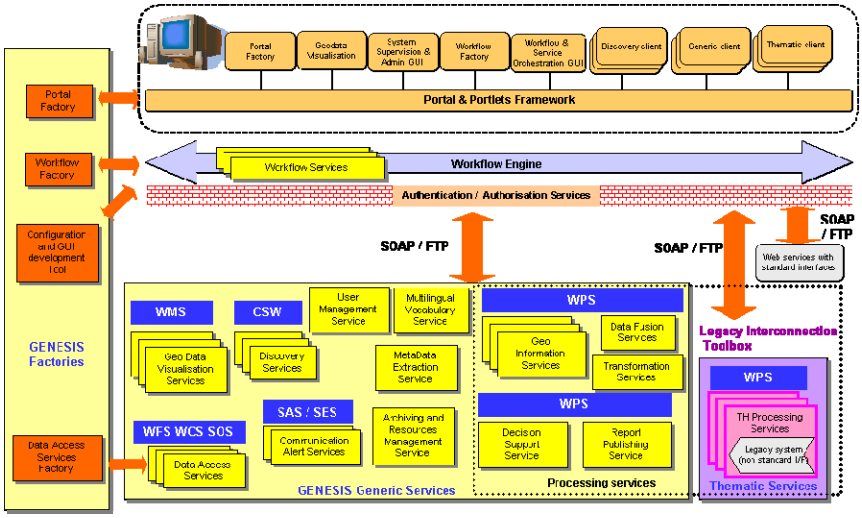

Figure 1 : GENESIS Architecture Overview

A specific WPS client portlet can be easily instantiated within this portal by providing the endpoint URL to the service and two XML files which can be automatically generated on the basis of the WPS Process Description file. The first file is used to transform the user input into a WPS Execute message and the WPS Execute Response message into presentable format. It is encoded as XSLT (Clark 1999). Within the second file, the User Interface of the WPS client is defined using facelets – the default view definition language for the Java Server Faces framework. On the basis of the data types of the different input parameters, specific User Interface control elements are proposed.

For WPS Services that require geographically referenced input data or provide georeferenced output, the GENESIS Geodata Visualisation Portlet System can be employed. This Portlet is included into the Web Portal and allows to instantiate varying geographical user interfaces for each GENESIS service client. It allows interacting via a map with OGC Web Map Service (WMS, Beaujardiere 2006), Web Feature Service (WFS, Vretanos 2005), Web Coverage Service (WCS, Whiteside and Evans 2008) and Sensor Observation Service (SOS, Na and Priest 2006) instances and reading data from a variety of vector and raster data formats. It offers the user a map display with advanced feature oriented query functionality, tabular and graph visualisation and also intrinsic support for the temporal dimension of data.

For processes that publish multiple data sets, use is made of the OGC Web Map Context specification (Sonnet 2005) to communicate the set of processing results to the Geodata Visualisation Portlet. In this case, the Web Processing service will publish its data to an OGC WFS, WCS and/or SOS and will create a Web Map Context Document that will be provided as output of the WPS.

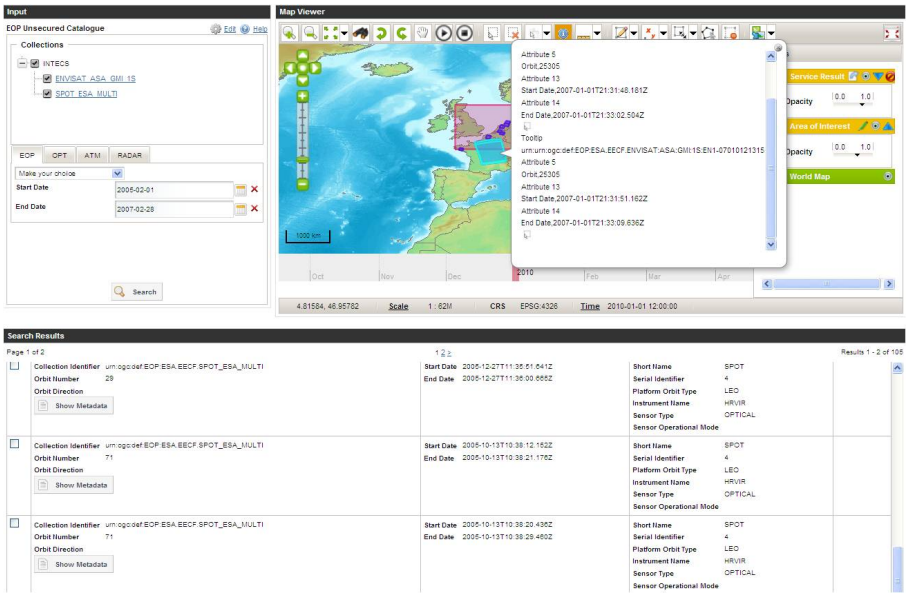

Figure 2: GENESIS Web Portal Client instance.

GENESIS Workflow Engine Orchestration Design GUI

The GENESIS Workflow Engine allows executing chains of web services i.e. workflows of several services where output from previous ones could be used as input of the next one. To reduce the complexity of designing service orchestrations, a GENESIS Orchestration Design GUI allows non-technical users to build orchestration workflows by drag-and-drop of preconfigured service instances onto a workflow area. This Orchestration Design GUI (Figure 3) produces workflow definitions according to the BPEL4WS1.1 (Andrews et al. 2003) and OASIS WS-BPEL2.0 (Alves et al. 2007) standards and deploys this output using a WPS-T Deployment Service that is built on top of the open source EasyBPEL engine and the Oracle BPEL engine.

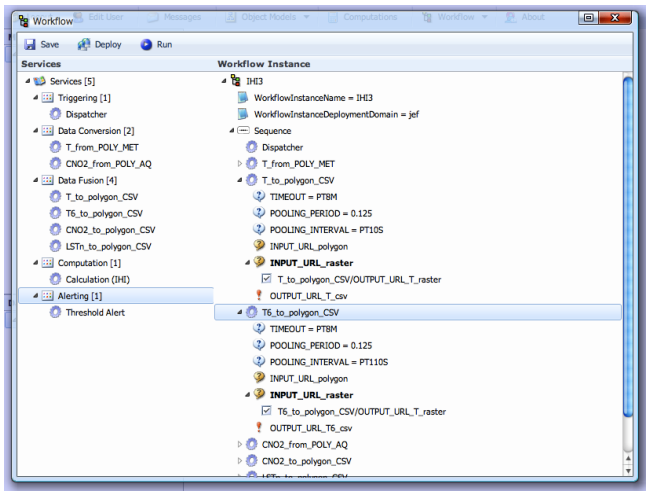

Figure 3: Orchestration design tool.

GENESIS Web Processing Services

The list of Web Processing Services developed by GENESIS consists of:

- The GENESIS Legacy Interconnection Toolbox that facilitates the publication of processes according to the OGC WPS specification by connecting legacy applications via shell scripts. A WPS instance is created via the DescribeProcess document. It parses the file and creates the resources needed to handle incoming WPS requests and converts them to allow the connection with the back-end processing engine. The toolbox also provides a web based testing and monitoring tool allowing for instance to list all the incoming requests evaluate their status and inspect the response messages.
- The GENESIS Geospatial Information Services provide generic geoprocessing functionality on geographically referenced vector and raster datasets. They offer advanced Geo Information System and Earth Observation functionalities for integration into Web-based Spatial Data Infrastructures. The processes that are implemented include raster and vector data clipping, (re-)projection, format conversion and generalisation, raster2vector and vector2raster conversion as well as imagery processing.
- The GENESIS Computation Service allows the execution of algorithms described in the OpenMath XML format. It enables the execution on various computation engines and provides an abstraction between an algorithm composition tool (or GUI) and the computation engine (in this case the Open Source Octave).

GENESIS Archiving and Resource Management Services

The above listed processing services produce results that may need to be archived for later discovery and access. This is one of the main functionalities of the GENESIS Archiving and Resource Management Services (ARMS) that address both the short-term and long-term archiving of the input data. The ARMS also provide the functionalities to retrieve previously stored datasets and to delete them. In addition the ARMS are also in charge of managing the metadata associated to the archived data. It can be seen as middleware software that encapsulates the publishing of data and metadata to a persistent web accessible store (HTTP, FTP, WCS or SOS) and allows managing the stored resources. An ARMS instance exposes itself as a Web Processing Service illustrating the generic nature of the Web Processing Service Specification.

GENESIS Sensor Fusion Service

The GENESIS Sensor Fusion Service constitutes the connecting component between the geo sensor web (i.e. Sensor Observation Service) and the more widely adopted WFS/WMS interfaces. The direct conversion of data structures allows the easy integration of sensor data into GIS applications and therefore enables fast and ubiquitous data visualisation and analysis.

From a technology viewpoint, the Sensor Fusion Service acts as a 'translator' between O&M-encoded measurement data (Cox 2007) and the provided OGC WFS/WMS output. During the transformation procedure, certain input parameters (coordinate reference system, units of measure, data structures etc.) are interpreted. Figure 1 illustrates the general functionality of the Sensor Fusion Service, which is realised as a custom data store for the open-source GeoServer.

GENESIS VALIDATION – PILOT APPLICATIONS

The GENESIS solution is validated on a number of pilots of which two examples are:

- The Bavarian Air Quality Pilot where earth observation and air quality forecast model run data are processed (clipping, format conversion, statistics over time, …) and combined to yield an Integrated Health Index map. One Catalogue Service and a set of four WPS instances are orchestrated from the central Workflow Engine. The processing services publish their

results to a WCS and an SOS to offer animated maps of this health index over time and time series graphs of this health index aggregated over regions.

- The GEOSS AIP3 Energy Pilot where the GENESIS Technology was used to establish a set of WPS server/client pairs to provide information on the environmental impact of the production, transportation and use of photovoltaic panels. Figure 5 shows how the Client Portlet allows user to select input parameters and to graphically define points of interest. A video showing the Energy GEOSS AIP 3 pilot is available on the GEOSS AIP3 home page (http://www.ogcnetwork.net/pub/ogcnetwork/GEOSS/AIP3/index.html).

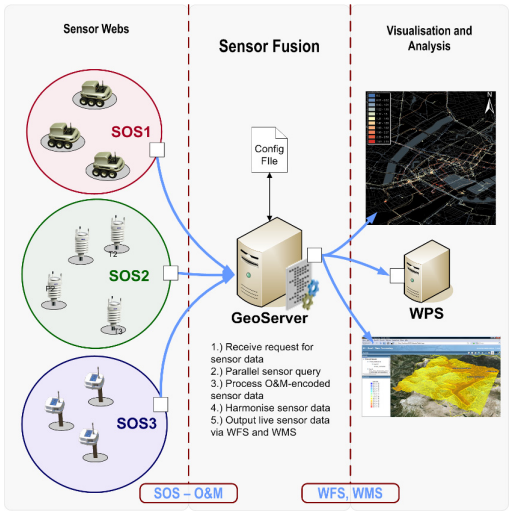

Figure 1: Sensor Fusion Service General Functionality.

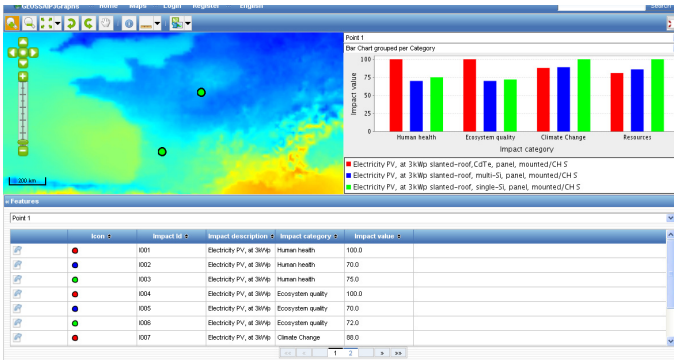

Figure 5: Example WPS Client Portlet: map tabular and graph display of WPS Results

CONCLUSION

The GENESIS solution proposes a complete set of components for building environmental information services. The system employs a loosely coupled Service Oriented Architecture with a central Web Portal and a set of distributed Web Services with Open Standards based interfaces. The OGC Web Processing Service standard is extensively used as protocol for addressing the various processing algorithms and for the utilisation of workflow engines. Furthermore it provides means to integrate sensor measurements and datasets into the rich environment. This allows to easily develop

and deploy web based environmental monitoring applications including sophisticated analysis functionality

ACKNOWLEGDEMENT

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REFERENCES

Alves, A., Arkin, A., Askary, S., Barreto, C., Bloch, B., Curbera, F., Ford, M., Goland, Y., Guízar, A., Kartha, N., Liu, C. K., Khalaf, R., König, D., Marin, M., Mehta, V., Thatte, S., van der Rijn, D., Yendluri, P., Yiu, A., 2007: Web Services Business Process Execution Language Version 2.0. Online available at: http://docs.oasis-open.org/wsbpel/2.0/wsbpel-v2.0.html (last access: 11.04.2011).

Andrews, T., Curbera, F., Dholakia, H., Goland, Y., Klein, J., Leymann, F., Liu, K., Roller, D., Smith, D., Thatte, S., Trickovic, I., Weerawarana, S., 2003: Business Process Execution Language for Web ServicesVersion 1.1. Online available at: http://public.dhe.ibm.com/software/dw/specs/ws-bpel/ws-bpel.pdf (last access: 11.04.2011).

Beaujardiere, de la, J., 2006: OpenGIS® Web Map Server Implementation Specification. OGC document number 06-042.

Clarl, J., 1999: XSL Transformations (XSLT) Version 1.0. Online available at: http://www.w3.org/TR/xslt (last access: 11.04.2011).

Cox, S., 2007: Observations and Measurements – Part 1 - Observation schema. OGC document number 07-022r1.

Gudgin, M., Hadley, M., Mendelsohn, N., Moreau, J., Nielsen, H. F., Karmarkar, A., Lafon, Y., 2007: SOAP Version 1.2 Part 1: Messaging Framework (Second Edition). Online available at: http://www.w3.org/TR/soap12-part1/ (last access: 11.04.2011).

Houbie, F., Skivée, F., Jirka, S., 2010: OGC® Catalogue Services Specification 2.0 Extension Package for ebRIM Application Profile :SensorML. OGC document number 09-163r2.

Lesage, N., 2007: OGC® Cataloguing of ISO Metadata (CIM) Using the ebRIM profile of CS-W. OGC document number 07-038.

Na, A., Priest, M., 2006: OpenGIS Sensor Observation Service Implementation Specification. OGC document number 06-009r1.

Primavera, R., 2008: OGC® Catalogue Services Specification 2.0 Extension Package for ebRIM (ISO/TS 15000-3) Application Profile: Earth Observation Products. OGC document number 06-131r4.

Schut, P., 2007: OpenGIS Web Processing Service. OGC document number 05-007r7.

Sonnet, J., 2005: Web Map Context Documents. OGC document number 05-005.

Voges, U., Senkler, K., 2007: OpenGIS® Catalogue Services Specification 2.0.2 -

ISO Metadata Application Profile. OGC document number 07-045.

Vretanos, P. A., 2005: Web Feature Service Implementation Specification. OGC document number 04-094.

Whiteside, A., Evans, J. D., 2008: Web Coverage Service (WCS) Implementation Standard. OGC document number 07-067r5.