Institute for Geoinformatics
University of Münster
Weseler Straße 253
D-48151 Münster

52° North WPS-G

A grid-enabled OGC Web Processing Service (WPS)

Bastian Baranski [1], Bastian.Baranski@uni-muenster.de

OGC-OGF Collaboration Workshop
The 22nd Open Grid Forum – OGF22
February 25-28, 2008

Abstract

When computation large amounts of data and do complex calculations, the use of grid computing is a good choice for achieving high performance. At first glance, it seems that the OGC's Web Processing Service (WPS) and its needs of computation resources is the perfect candidate to benefit from grid technologies. In this report we'll present a proof-of-concept implementation of a grid-enabled WPS. The introduced solution and the concept behind it is one step forward into a full grid-enabled spatial data infrastructure (SDI).

OGC Web Processing Service (WPS)

The OGC's WPS specification defines a standardized interface to publish and perform geospatial processes over the web. Such a process can range from a simple buffer calculation to a complex process of vector analyses for generalization purposes. The interface to a WPS is based on three operations. The GetCapabilities operation provides service metadata and a general informations about the offered processes. The process metadata including the corresponding input- und output-parameters are provided by the DescribeProcess operation. Via the Execute operation it is possible to run a process.

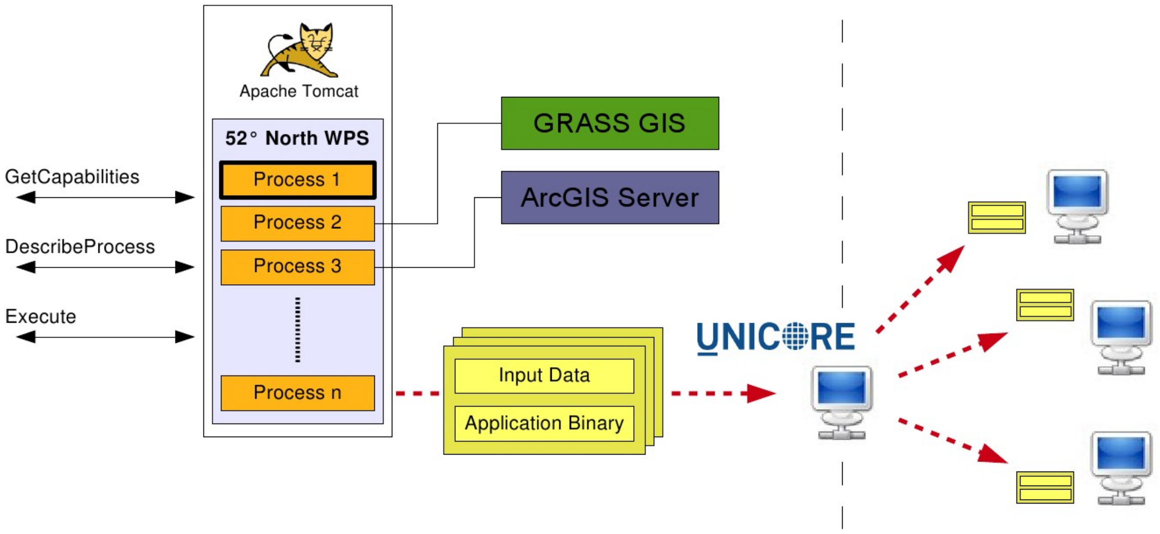
A typical WPS implementation supports all feature of OGC's WPS specification and the offered processes and algorithms run local inside an application-server. There is use of geo-specific third-party libraries or other mainstream GIS, but there is typically no use of grid technologies. The 52°North Web Processing Service [1] is such an implementation. The new release is compliant to OGC's WPS 1.0.0 and includes the WPS server, the uDig [2] client plug-in and the JUMP [3] client plug-in. Former versions of this implementation perform reliable in many research and commercial projects. Schäffer presents in [4] an extension of the WPS specification which allows the chaining of multiple WPS to a single geoprocessing workflow. Among other things he developed a workflow-enhancement of 52° North's implementation and a uDig client plug-in for modeling complex workflows.

1The author's working group at Institute for Geoinformatics (ifgi) at University of Münster focuses on the conceptual development of geodata and spatial data infrastructures (SDI) in collaboration with the international standardization bodies, the development of architectures and methods for stationary and mobile sensor networks (Sensor Web Enablement, SWE), the linking of sensor web services with spatio-temporal simulation models and the development of security services. A new area of research is to extend the grid knowledge. The research activities aims at bringing the OGC services into the grid, finding general synergy effects between the geo- and the grid-world and to create momentum in the geo-community as well in the grid-community.

Grid-enabled WPS

The proof-of-concept implementation of a grid-enabled WPS introduced in this report is based on 52° North's implementation as well. The architecture overview of such a simple grid-enabled implementation of OGC's WPS specification is shown in Figure 2.

There exist different kinds of gridification. In a simple approach the grid is used as a simple computation resource, therefore the application (the WPS-G server in this context) moves the calculation process from the local processor into the grid. For this reason all application binaries and all input data must be copied to the computation node in the grid. The grid-enabled WPS introduced in this paper detects automaticly which application binaries and which third-party libraries will be needed for the calculation job and copies them to the computation node. Then the calculation will be startet (at the computation node in the grid) and the server will wait for the calculation results. If the calculation process is finished, the results will be fetched and the WPS carry on like the normal way.



Figgure 1: Architecture of a grid-enabled implementation of OGC's WPS specification

Using the grid as a computation resource is only a first step forward into a full grid-enabled SDI. To benefit more of the grid skills, you have to develop „real" grid services (e.g. a stateful WSRF service). But there is currently no common approach available how to gridify OGC services and already stay OGC compliant.

Features

The WPS-G is a powerfull enhancement of the open source implementation of 52°North's WPS. It is public available as open source as well and has – together with other extensions - the following features:

- The classical 52°North WPS enables the deployment of web-based geo-processes and has full support of all OGC's WPS specification (version 0.4.0 and 1.0.0) features. The development of processes and algorithms can simply be done in Java.
- The 52°North WPS-T supports the chaining of multiple WPS to a single geoprocessing workflow. A uDig client plug-in for modeling these complex workflows is available.
- The new 52°North WPS-G enables the 52°North WPS with grid abilities. Any existing processes and algorithms can be reused and now distributed over the grid. The UNICORE 6 grid middleware is supported and the connection to other grid middlewares (e.g. Globus Toolkit 4) could easily be done.

There is no need of administrative access to the grid, only a valid certificate for the target system is required.

The implementation work is still ongoing and the following features are planed:

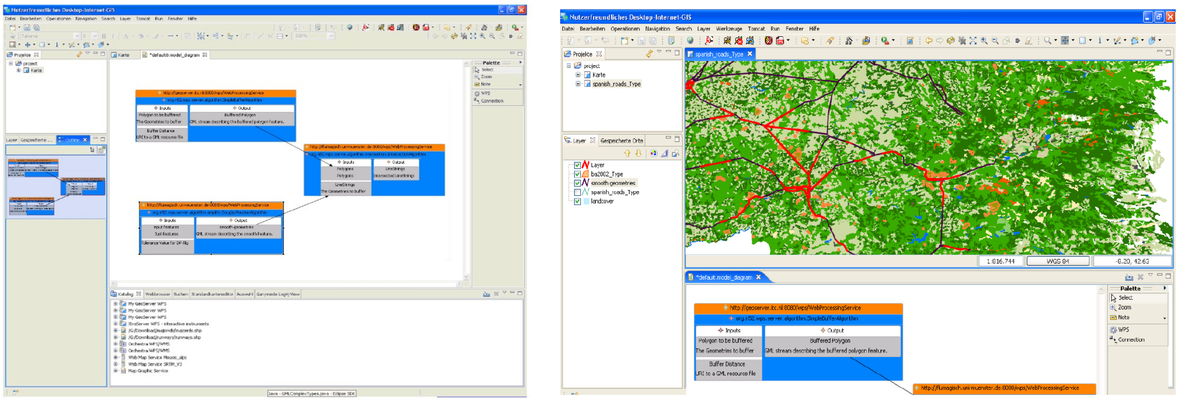
- support for other mainstream GIS (e.g. GRASS GIS and ArcGIS)
- support for other mainstream grid middlewares (e.g. Globus Toolkit 4)

We are always interested in new research questions or practical user requirements. Please contact the author(s) of this report if you have any further questions or wishes for new features.

Demo-Scenario

The selected demo scenario from [5] aims at producing an automated model to generate a readable map which indicates recent fire threats to transport infrastructure. The scenario involves data about fire threat areas (i.e. areas where fire has been reported) and road data. It inherits aspects of a real-time risk-management application, as different data sources have to be integrated and processed in order to improve decision making. The chosen location for this scenario is the North-West of Spain. The data for the burnt areas are provided by the courtesy of the Joint Research Center in Italy and served through a WFS. The roads of Spain are taken from CORINE data, provided and served through a WFS from the International Institute for Geo-Information Science and Earth Observation (ICT). In order to produce a satisfying map we also incorporated some CORINE landcover data, served through a WMS.

The calculation, which roads are at stake by a fire threat, is designed as a workflow of several smaller calculation steps. At first, buffers have to be created around the burnt areas. Second, as the roads are too detailed to be displayed on a general overview map, a simplification has been applied to the roads and finally be intersected with the buffered burned areas. The first two steps in the workflow will refer to a classical WPS which offers the needed processes. The final step in the workflow will refer to a simple grid-enabled WPS. This WPS-G will split the input data and distribute the intersection calculation as several parallel jobs over the grid. It is important to note, that this demo scenario is completely based upon distributed web services and that one of these web services do his calculcation job in the grid.



Screenshot 1: The selected demo scenario from [5] produce a readable map which indicates recent fire threats to transport infrastructure. The workflow modeller [4] [5] can be used to visually compose a workflow by only entering the WPS URLs, selecting and connecting the desired process while the WPS client can be used to execute that workflow.

The screencast from [6] shows the whole processing workflow and the interactions between the user and the client. The hands-on tutorial from [7] explains how to set up the server on your local machine and how to reproduce the demo scenario. The cookbook from [8] explains how to develop your own grid-enabled processes and algorithms.

Research

The following list is only a short outtake of interesting topics for further researches.

- Desktop Grid Computing

  Estimated 90% of computing resources are idle at current desktop computers. The upcoming of multi-core CPU's on simple desktop computers enforces this situation. The motivation behind projects like BOINC [9] is to use unused CPU cycles on desktop computers, to do e.g. scientific computing or other useful jobs. The advantages of such an approach are evident. There is an existing infrastructure (e.g. personal computers at government agencies) and the administration needs for extending this infrastructure with grid capabilities are low. On the other side such an approach is unsuitable in time-critical scenarios.

- Geoprocessing Workflows

  As wrote before, the use of grid technologies is a good choice for achieving high performence when computation large amounts of data and do complex calculations. The main bottleneck when using the grid as a computation resource is the stagein and stageout phase before and after the job's running phase. During the stagein phase, all the application binaries and the corresponding input-data must be transferred from the grid client to the computation node. After the job's running phase, all the output-data must be transferred back from the computation node to the grid client. If there is e.g. a complex processing workflow, a situation in which the input- and output-data where copied many times can occur. A meta-schedular should avoid those situations. Sometimes the application should come to the data (to the computation node, where the data lies), so that the copy overhead not appear. There already exist some basic approaches and solutions for such problems, but the usefulness for geoprocessing workflows and the special needs of geoprocessing workflows must be examined in further researches.

There are many other skills of grid-computing which are possible suited for creating synergy effects between the grid- and geo-world. For instance topics like Quality Of Service (QoS), Service Level Agreement or Grid Security maybe relevant in context of a grid-enabled SDI. More fundamental researches on these topics will have to be made.

References

Notice: Due to the early stage of the project there is a deficit of documentation. Not all referenced documents are currently available, but the documentation work is still ongoing. If you have furthermore questions, please contact the author(s) of this report.

[1] http://www.52north.org
[2] http://udig.refractions.net
[3] http://www.jump-project.org
[4] B. Schäffer, *Integrated Web Geoprocessing Workflow Composition and Deployment*, Diploma Thesis, 2007
[5] B. Schäffer, T. Foerster, *A Client for Distributed Geo-Processing and Workflow Design*, 2008, (in print)
[6] Screencast will be available as from March 2008 at http://52north.org
[7] Hands-on tutorial will be available as from March 2008 at http://52north.org
[8] Cookbook will be available as from March 2008 at http://52north.org
[9] http://boinc.berkeley.edu
[10] OGC, 2007: OpenGIS Web Processing Service. OpenGIS standard, OGC 05-007r7