Web Generalisation Service in GiMoDig – Towards a Standardised Service for Real-Time Generalisation

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SUMMARY

The increased use of spatial data in the Internet is facilitated by standardised Web Services for the selection, access and presentation of spatial data. Transmitting large quantities of spatial data, however, demands for efficient reduction of the data sets and presentation of the data on an appropriate level of detail, which can be achieved by generalisation functions. Cartographic readability of a displayed map set similar requirements. These, therefore, demand for an internet service for generalisation. In the context of the GiMoDig project, a prototype of such a generalisation service has been developed and implemented. This prototype can serve as a step towards a standardised generalisation service.

KEYWORDS: *generalisation, standard, web-service, interoperability*

INTRODUCTION

The background for this research lies in the objectives of the GiMoDig (Geospatial info-mobility service by real-time data-integration and generalisation) project, which has aimed to improve the accessibility and interoperability of national topographic databases (GiMoDig, 2004; Sarjakoski et al., 2002). A prototype for a cartographic map service has been built which delivers geospatial data to a mobile user in real-time. The data is delivered from the geo-databases in the participating countries' NMAs (Finland, Sweden, Denmark and Germany), where the common interfaces are based on XML-coded (Extensible Mark-up Language) data delivery and OGC's specifications (Open Geospatial Consortium). The data is harmonised according to the Global Schema, defined during the project, and transformed into the common ETRS89 coordinate system in real-time. Finally, a vector-formatted high quality SVG (scalable vector graphics) map is displayed on a users' mobile device. Special emphasis has been placed on proving users, who depend on mobile terminals with limited display capabilities, with appropriately generalised map data. The benefit of the use of pre-generalized data in an MRDB (multiple representation / resolution database) has also been investigated in the project.

In the OGC's work concerning the general service architecture (OGC Web Services initiative, OWS) a service categorisation has been drafted (see OGC, 2004). In that classification a feature generalisation service is proposed. The only documentation of an implemented generalisation service that the authors have found is Burghardt et al. (2005). A sketch of an generalisation interface is also proposed by the Canadian project GeoConnections (GeoConnections, 2004).

In this paper we describe a generalisation interface as implemented in the current GiMoDig prototype (Sester et al, 2004). The foundation of the interface is the OGC's Web Feature Service (WFS) which has been augmented to include a portion to control the generalisation process. The OpenLS Presentations Service has also influences the design and functionality of the interface (OpenLS, 2004). It is clear to the authors that the generalisation interface presented in this paper is still only a demonstrative one which can be used as a starting point when discussing the features of a more complete and finally standardised web generalisation specification.

GIMODIG SERVICE ARCHITECTURE

In the GiMoDig project a prototype system has been designed and implemented for verifying the validity of the approach. A detailed illustration of the GiMoDig service architecture is shown in Figure 1 (GiMoDig, 2004; Lehto and Sarjakoski, 2004).

Query processing

The client platforms considered in the project include traditional web browsers in desktop computers, a GiMoDig-specific SVG-based client run on PDAs and Java MIDP clients on mobile phones. The service access on the Value Added Service (VAS) layer will be based on a proprietary, use case-specific query interface (Sarjakoski and Sarjakoski, 2004). One of the main research topics in this respect is the use of context parameters for adaptive map displays (Nivala and Sarjakoski, 2003). These parameters could include detailed information on the user's age, position and current activity and about the mobile device being used in the query (Sarjakoski et al., 2004).

The context parameters need to be translated into a set of appropriate overlay queries to add required Point of Interest (PoI) and other relevant information to the map display. After conducting the external queries, the VAS layer can add to the Portal Service query all the overlay information to be visualised on top of the map, as determined in the OpenLS Presentation Service specification. It is the responsibility of the Portal Service to translate the map query coming from the VAS layer into an appropriate WFS data query, expressed in terms of the GiMoDig Global Schema. At the same time, the Portal Service must decide on the generalisation to be applied, based on display scale and level of detail (LoD) information provided by the VAS layer.

Access interface of the Data Processing Service layer (DPSL) is specified in the GiMoDig project, since a commonly accepted query interface for a spatial data generalisation service does not exist. This interface will include a portion to indicate the WFS query providing the source dataset for the generalisation process, and a set of detailed instructions and parameters to guide the generalisation computations. The generalisation query interface will also provide facilities to carry over map overlay information, in case it must be included in the generalisation process.

The Data Processing layer will forward the WFS section of the Generalisation query directly to the Data Integration Service layer. The Integration Service must subsequently translate the incoming query to the national data models and coordinate systems as well as send the queries to the relevant national WFS nodes, as determined by the spatial extent of the query window. The transformations from the Global Schema to the national data models are carried out as declarative XSL Transformations (Lehto and Sarjakoski, 2004).

Response processing

The lowest layer of the service architecture contains the four national WFS nodes, one in each of the GiMoDig participant countries: Finland, Sweden, Denmark and Germany. These services provide data in the national data models and coordinate systems, encoded in the form of a GML Application Schema. The Data Integration service and all the service layers above it are currently running on the GiMoDig main server at the Finnish Geodetic Institute.

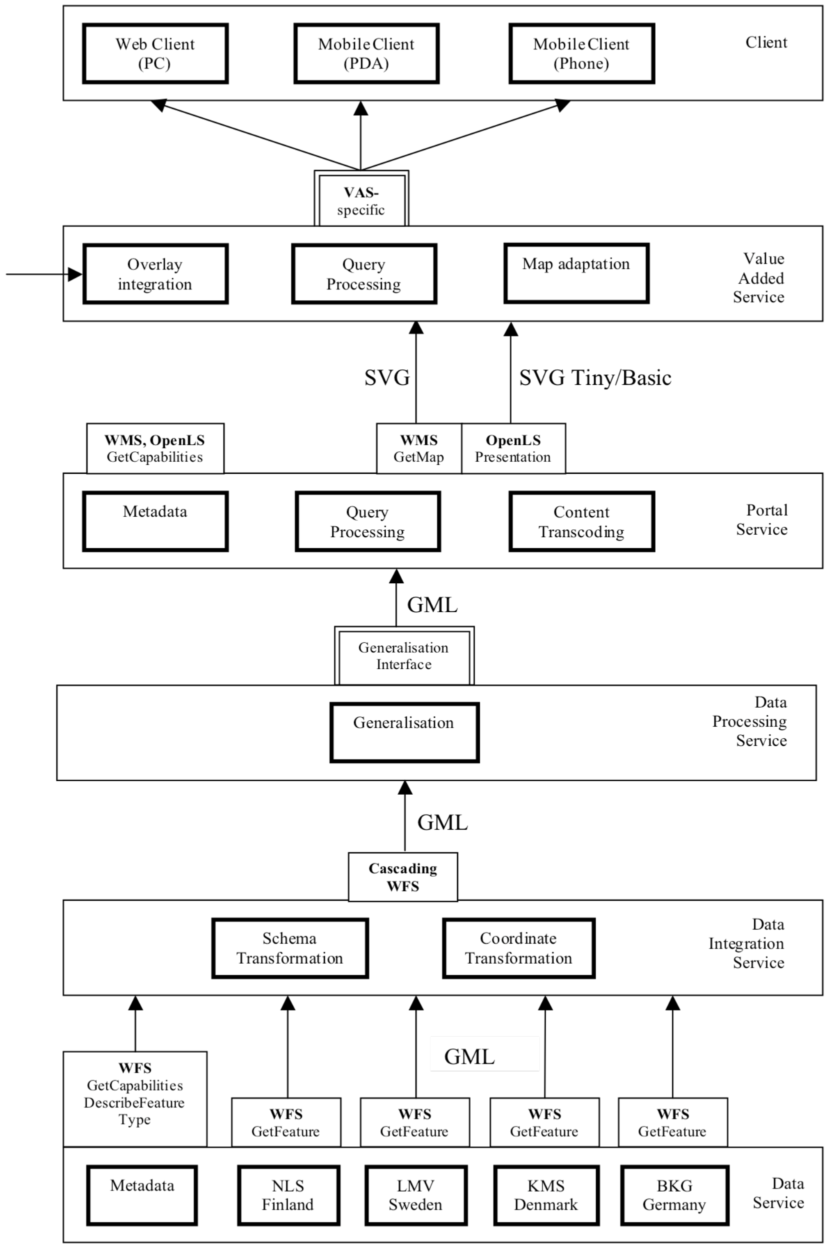

Figure 1. The detailed GiMoDig service architecture (Lehto and Sarjakoski, 2004). The arrows indicate the direction and encoding of the reply messages, while the arrows for requests have been omitted. The Value-added Service (VAS) layer can access external databases e.g. for retrieving Point of Interest (PoI) data. The access interfaces are based on Open Geospatial Consortium Specifications, except the VAS and Generalisation Interface, which have been developed in the project.

Following the processes carried out by the Data Integration layer, the response data are expressed in the form of the GiMoDig Global Schema and in the common ETRS89 coordinate system. XSL Transformations are defined from each of the national datasets to the common data model. A Cascading WFS interface provides a single access point to all four national topographic databases; thus the service response is encoded in GML form.

In the GiMoDig project, the main responsibility of the Data Processing layer is to generalise the spatial data. The dataset received from the Data Integration layer is uploaded to the JTS Topology Suite platform, which is a processing tool providing sophisticated geometric and topologic algorithms for generalisation processes (JTS 2004), (Harrie and Johansson, 2003). After the real-time generalisation phase, the results are still expressed as GML-encoded spatial data that may also include PoI data as GML Features.

After receiving the generalised dataset from the Data Processing Service layer, the Portal Service translates the data into a map image, taking into account the styling properties indicated as in the OpenLS Presentation Service query. This process is also carried out as an XSL Transformation. The Value-added Service layer will acquire the resulting map from the Portal Service layer in the form of an SVG image. Depending on the client application's capabilities, the VAS layer may transcode the image into raster form, add user interface components, scripting code for local processing etc, and finally returns the results to the client.

GENERALISATION INTERFACE IN GIMODIG

Responsibilities of DPSL

The Data Processing Service is responsible for real-time generalisation on algorithm level. It also merges overlay data into the actual spatial data. First DPSL loads geographic data and merges overlay data into it. Then it executes the given sequence of algorithms to process data and returns data in GML format. The execution flow of a Data Processing Service is the following: 1) Read the query from HTTP-POST data, 2) Parse query, 3) Connect to WFS and load data, 4) Read data into JTS/JUMP, 5) Select algorithms and initialize parameters, 6) Execute algorithms, 7) Write data from JTS/JUMP into output.

According to the principle of OpenLS Presentations Service, the overlay data is incorporated into the query. In the GiMoDig, the concept of Points of Interest (PoI) has been extended to Lines of Interest (LoI) and Areas of Interest (AoI). The Value-added Service adds the PoI data into the query and passes it to the DPSL. The DPSL merges the two data sets so that they can be processed simultaneously. This has been visualized in Figure 2.

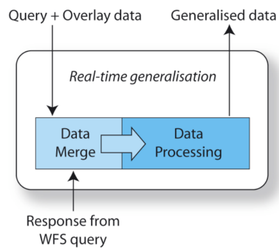

Figure 2. Real-time generalisation in DPSL can divided into two phases: once the Value-added Service has added overlay data into the query, DPSL has to merge with spatial data requested from Data Integration Service. After this, DPSL processes this merged data and returns the generalised data.

Architecture

The geometric and topological processing in DPSL is done using JTS/JUMP. The JTS Topology Suite (JTS, 2004) is an open source Java API of 2D spatial predicates and functions. It conforms to the Simple Features Specification for SQL published by the Open Geospatial Consortium. The JTS provides a complete, consistent, robust implementation of fundamental 2D spatial algorithms. The Unified Mapping Platform (JUMP, 2004) is a graphical user interface-based application for viewing and processing spatial data. It includes many common spatial and GIS functions as well as a GML parser. It is also designed to be a highly extensible framework for developing and running custom spatial data processing applications. JUMP uses the JTS Topology Suite to provide an OGC-compliant spatial object model and the fundamental geometric operations.

The DPSL service is implemented as Java servlet DPSLMain, The main classes can be seen in Figure 3. The AlgorithmManager class makes sure that the desired algorithms will be executed with the given parameters. All parameters passing to the algorithms will be done using class AlgorithmContext. The interface to JUMP and JTS data structures is dealt with the class FeatureCollectionManager. It wraps all the geometrical and attribute data inside so that algorithms have unlimited access to them.

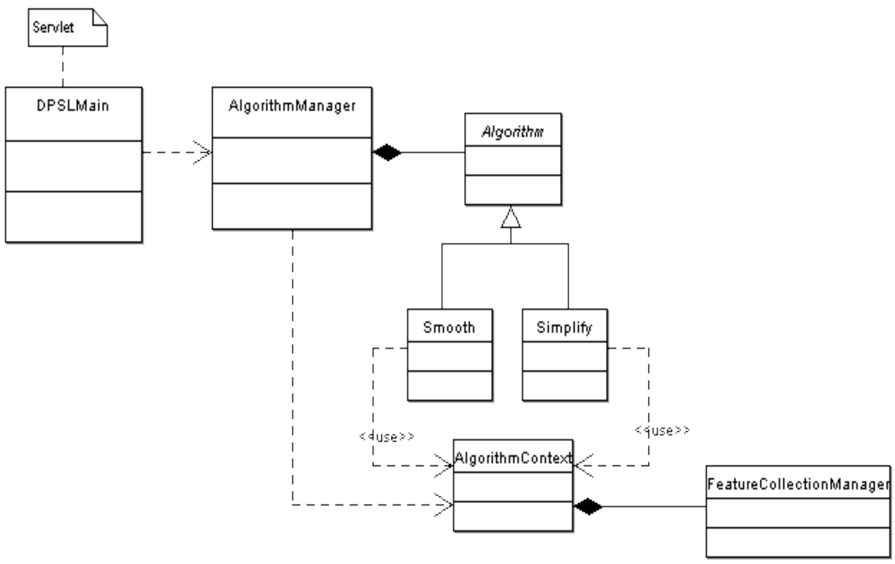

Figure 3. Class diagram of algorithms in Data Processing Service. The main class DPSLMain delegates the control of different algorithms to AlgorithmManager class. It has instances of all algorithms loaded into the system and it calls them with the use of AlgorithmContext class which contains all the parameters needed.

Query interface

The DPSL has a generic interface to decide in query time what generalisation operations are done and which parameter values are used. Queries into this service are done in the form of XML. The query contains a WFS query for querying the data and parameters for data processing. It also makes possible to transfer PoI -data and the position of the user into the DPSL. The structure of the Data Processing Service query is shown in Figure 4.

```xml
<?xml version='1.0' encoding='iso-8859-1'?>
<gen:GetGeneralised xmlns="http://www.opengis.net/wfs"
          xmlns:gen="http://gimodig.fgi.fi/gen"
          xmlns:xls="http://www.opengis.net/xls">
 <gen:WFSQuery>
  <GetFeature>…</GetFeature>
 </gen:WFSQuery>
 <gen:GeneralisationParameters>
  <gen:Parameter name="PARAM" value="VALUE"/>
  .
  .
  <gen:Operator name="OPERATOR_NAME" order="EXEC_ORDER">
   <gen:Parameter name="OPER_PARAM" value="OPER_VALUE"/>
   .
   .
   <gen:Target filter="FILTER_TYPE">
    <gen:FeatureType name="FEATURE_TYPE" />
    .
    .
   </gen:Target>
  </gen:Operator>
  .
  .
 </gen:GeneralisationParameters>
 <gen:Overlays>
  <xls:Overlay>…</xls:Overlay>
  .
  .
 </gen:Overlays>
</gen:GetGeneralised>
```

Figure 4. This is the basic structure of DPSL query. It contains the WFS query to be forwarded into Data Integration Service. Then generalization parameters define the generalization process. It may consist of global parameters, data processing operators, their parameters and target feature sets. Finally, the query may contain overlay information to be merged in the process.

A WFS query is inside the gen:WFSQuery element and it is passed directly to the WFS service. PoI-data and the user position coordinates are inside the gen:Overlays element. The structure of xls:Overlay elements is described in the *OpenGIS Location Services specification*.

Actual data processing is described with the Operator elements. There can be many operators – even with the same OPERATOR_NAME. EXEC_ORDER attribute describes the execution order of operators. The Operator that has the smallest execution order value (should be 0) will be executed first. Every operator can have parameters of its own. They are described by the Parameter elements inside the Operator element and treated similarly as global parameters.

The target features of an operator are selected by the element Target. FILTER_TYPE attribute can be either ‘Include’ or ‘Exclude’. In an inclusion target group will be the feature types listed in FeatureType elements. In an exclusion target group will be a group of all feature types except the listed ones. By using excluding filter and leaving the containing of the Target element empty or by leaving the whole Target element out includes all feature types. A query may look like the one in Figure 5.

```xml
<?xml version='1.0' encoding='iso-8859-1'?>
<gen:GetGeneralised>
 <gen:WFSQuery>
  <GetFeature outputFormat="GML2" handle="GiMoDigQuery">
   <Query handle="query0" typeName="Road" version="1.0">
    <PropertyName>centerLineOf</PropertyName>
   </Query>
  </GetFeature>
 </gen:WFSQuery>
 <gen:GeneralisationParameters>
  <Operator name="Douglas-Peucker" order="0">
   <Parameter name="threshold" value="5.0"/>
  </Operator>
  <Operator name="Gauss-filtering" order="1">
   <Parameter name="distance" value="10.0"/>
   <Parameter name="kernelShape" value="0.00001"/>
   <Parameter name="kernelSize" value="3"/>
   <Parameter name="numPoints" value="2"/>
   <Parameter name="extrapolation" value="1.0"/>
  </Operator>
 </gen:GeneralisationParameters>
 <gen:Overlays>
   <Overlay>
    <POI ID="POI.Finland.1762059" POIName="Campsite">
     <gml:Point>
       <gml:pos>362236.937 6688534.245</gml:pos>
     </gml:Point>
   </POI>
   </Overlay>
   <Overlay>
   <POI ID="POI.Finland.1762060" POIName="Fireplace">
     <gml:Point>
      <gml:pos>362240.384 6688496.551</gml:pos>
     </gml:Point>
  </Overlay>
 </Overalays>
</gen:GetGeneralised>
```

Figure 5. A simple example of complete DPSL query. It requests for road features and generalises them using Douglas-Peucker line simplification and Gauss-filtering smoothing. In the overlay part, ‘Campsite’ and ‘Fireplace’ have been included as PoIs to be merged into the generalization process.

Declaration of generalisation functions

In the GiMoDig DPSL a set of some basic operators for generalisation have been implemented for demonstrating the functionality of the approach. The architecture of DPSL is independent on the actual data processing algorithms used since it has fully pluggable algorithm interface, which serves as a kind of application programming interface for the system administrator. This way new algorithms can be easily introduced into the service without changing the architecture.

DISCUSSION

In this paper we have described a web generalisation service as implemented in the GiMoDig prototype. When judging its general applicability for web-based real-time generalisation, several observations can be made. First of all, the approach follows the principle of a cascading WFS so that the target data will be specified in the query which is then forwarded to the appropriate feature server. In addition to this, the overlay data will be brought to the generalisation process as a part of the query, like in OpenLS Presentation Service specification. This combined approach seems to be quite feasible because all the data can be treated simultaneously, which is needed in more complex generalisation tasks.

In the presented approach the generalisation task is defined by listing the specific algorithms, along with their parameters and execution priority, and targeted to desired feature classes. It is clear that the current set of operators is no way complete but should be extended to cover some other operators as well. The approach as such seems to function rather well, because it allows a client to specify the required generalisation task on detailed level. On the other hand, the approach moves the responsibility of the overall quality and level of detail of the generalised data to the client. In the GiMoDig prototype this knowledge is hidden within the VAS layer.

The level of abstraction of the generalisation service could be increased from the presented one by introducing a generalisation interface specification so that the query would indicate only the desired overall level of detail for the data, without specifying exactly how the goal should be reached. Developments towards this kind of approach are a subject of further studies and beyond the scope of this paper. It should be noted that the underlying feature servers should be based on multiple representation database approach, because real-time generalisation over a very wide scale range can still be forecasted to remain beyond the capabilities and capacities of the systems.

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