Cascading Geospatial Content Services

CASE: European Location Framework

Lassi Lehto
Department of Geoinformatics and Cartography
Finnish Geospatial Research Institute, NLS Finland
Masala, Finland
e-mail: lassi.lehto@nls.fi

***Abstract*— The concept of service cascade can be seen as a solution for the data aggregation needs set forth for instance by the basic INSPIRE principle, according to which European level Spatial Data Infrastructures (ESDIs) can be built on top of national level SDIs. The research described in this paper has been conducted in the context of a major EU project, called European Location Framework (ELF). The main goal of the work discussed in this paper has been to facilitate European level access to national master datasets using direct access download services that conform to Web Feature Service (WFS) specification. Content aggregation is based on the Cascading WFS approach and carried out as on-the-fly process. Service cascade is not formally specified in the WFS standard, thus the ELF Cascading WFS has to be taken as an experimental implementation with some significant limitations. Altogether 83 national download services have been successfully included into the ELF Cascading WFS, providing access to over 120 different feature types from 11 INSPIRE themes in 13 European countries.**

Keywords-service cascade; content aggregation; Web Feature Service; European SDI.

I. INTRODUCTION

Providing aggregated European-wide access to geospatial data resources maintained on national level is the ambitious goal of the INSPIRE process (Infrastructure for Spatial Information in the European Community) [1] and other similar integration initiatives. Service cascade is presented in this paper as a solution for facilitating access to national content to support Pan-European applications. The paper presents the process of providing a centralized access point to geospatial data, requested from several national INSPIRE-compliant Download Services [2].

The research described in this paper has been carried out in the context of a major EU project, called European Location Framework (ELF), initiated by EuroGeographics (EG), the European level representative of the European National Mapping and Cadastral Agencies (NMCAs) [3]. The ELF project aims at developing European-wide INSPIRE-compliant services based on geodata resources maintained by the EG's membership. The ELF project started in March 2013 and ended in October 2016 [4]. The project has 30 participant organizations, 13 of them representing EU/EFTA member states as official NMCAs. Thus the data resources accessible by the project have quite extensive spatial coverage across Europe, see Fig. 1.

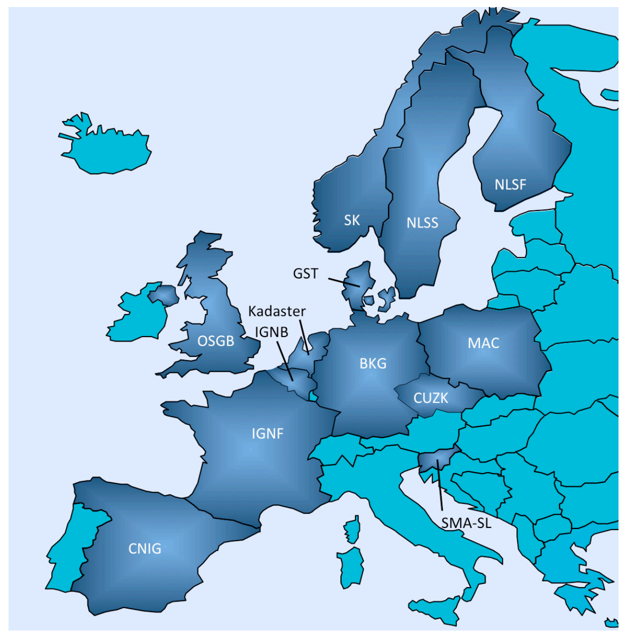

Figure 1. The countries participating in the European Location Framework project. The label indicates the National Mapping and Cadastral Agency (NMCA) of each country.

The ELF project includes a work package specifically focusing on data provision and service development. In this work package there is a subtask that focuses on the issues related to service cascade [5]. The author of the paper has been responsible for this subtask in the ELF project. The approach presented in this paper covers this development and discusses specifically the provision of European level download services based on data services delivering content on national level. The approach is based on the principle of a Cascading Web Feature Service (WFS) [6].

Section II introduces the concept of service cascade and its implementation in the download services of the ELF platform. Section III provides a more detailed description of the ELF Cascading WFS module and Section IV discusses its most significant limitations. The paper ends with concluding remarks in Section V.

 ISBN: 978-1-61208-539-5

II. Service Cascade

A. Principle

The concept of service cascade is discussed in this paper, as a solution for data aggregation needs. According to the service architecture model of the Open Geospatial Consortium (OGC), the basic idea in service cascade is that a service access point can be configured as a content source for another service, actually making this latter service a client of the source service [7]. Service cascade can be regarded as an implementation of the basic INSPIRE principle, according to which European level Spatial Data Infrastructures (ESDIs) can be built on top of the national level SDIs. This can be seen as the most cost-effective way for building services on multiple levels of local administration inside a single country as well. In the past, service cascade has been studied for instance in the context of metadata service integration [8].

B. Query Distribution

When implementing cascaded integration over a set of national services, one has to resolve the problem of spatial query distribution on one hand, and the cross-border fusion of geospatial content on the other.

The main tasks of the ELF Cascading WFS component is to determine, to which national services the incoming WFS GetFeature –query must be forwarded, depending on the location of the query's bounding box (query window) and the requested feature types. The bounding box of the query is overlaid with the polygonal national boundaries dataset stored in the ELF Cascading WFS's local PostgreSQL/PostGIS database. As a result, all countries involved in the query are identified. Then the requested feature types are checked to determine, which country level services have to be queried. The ELF Cascading WFS approach is depicted in the Fig. 2.

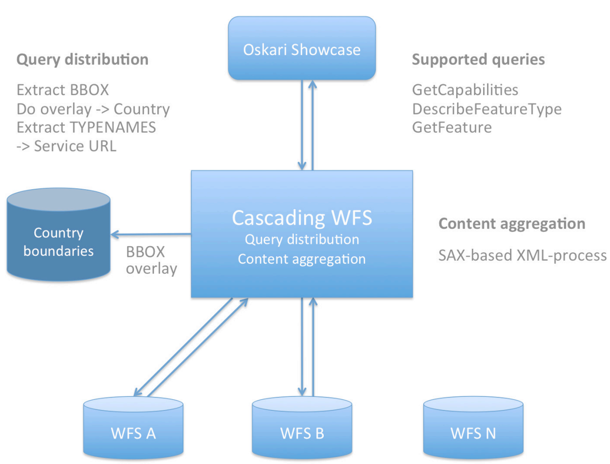

Figure 2. Cascading WFS service architecture of the ELF platform.

C. Content Aggregation

The goal of the ELF platform is to support the end user in accessing geospatial data content aggregated on the European level, and directly from national services, too. Thus, the cascading approach aims at supporting real-time aggregation of content from a set of distributed national data sources. One of the new challenges encountered, when accessing national services from European-level applications, is the need to introduce spatial integration capabilities to the traditional service cascade approach. At the moment only thematic integration is supported in the existing cascade mechanisms of the OGC service implementations (Web Map Service, WMS) [9]. In that setup, every single map layer is served by one and only one back-end service.

If only one backend service is involved in the Cascading WFS query, the process is straightforward. The single service is accessed, and the resulting dataset is returned to the calling application without further processing. However, if two or more services are involved in the case of a cross-border query, the Cascading WFS dispatches several parallel query threads to access the national services. The returning data streams are processed in the order they become ready. The datasets are merged into a single response message stream using a SAX-based XML-processing model [10], as depicted in Fig. 2.

The Cascading WFS has to create the root element (FeatureCollection) of the resulting dataset and include all required XML namespace declarations. In addition, the Cascading WFS fills in the boundedBy-element using the bounding box of the query, as a rough indication of the spatial extent of the resulting dataset. Then the content streams of the individual background responses are written out in the order they become ready, taking away the FeatureCollection and boundedBy-elements from the individual streams. Finally, the FeatureCollection element is closed by the Cascading WFS.

As the source data sets conform to the data models defined in the INSPIRE schemas and the extensions developed in the ELF project, data content is semantically harmonised already on the state level. Content aggregation done on the cascading level thus does not need to be concerned about the semantic harmonisation of the data sets to be aggregated. Issues related to edge matching of content on the border were not treated in this subtask of the ELF project.

D. Client Applications

The ELF Cascading WFS functionality has been tested with a wide set of test queries using a standard Web browser. The POST-queries have been tested from browser using a service-side POST-module that forwards the queries to the service interface. In addition, the Cascading WFS has been successfully tested with the QGIS client application with the WFS 2.0 plugin installed [11]. Integration with a showcase application based on the Finnish Open Layers-derived map client library, Oskari, has also been tested [12]; see Fig. 2.

III. Implementation

The Cascading WFS implementation is currently running on the governmental cloud platform of the Norwegian NMCA, as a Java Servlet on top of a Tomcat Web application server. Backend national services are queried by

 ISBN: 978-1-61208-539-5

simultaneously dispatching a set of threaded query processes. The responses are returned to the client application in the order they become ready.

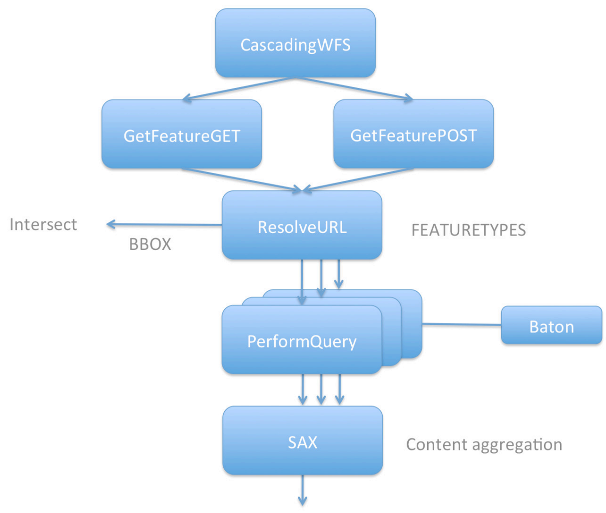

Figure 3. Internal structure of the ELF Cascading WFS implementation.

A baton-based approach is used to prevent parallel threads from writing to the response stream simultaneously. The fact that backend queries are run in a parallel fashion introduces a potential performance benefit to the system, when compared with the traditional way, in which the individual country level services are queried in a sequential manner. Exact values for the performance gain have not yet been determined. The internal modules of the ELF Cascading WFS implementation are depicted in Fig. 3.

IV. LIMITATIONS

The ELF Cascading WFS access interface has certain significant restrictions. Most importantly, it requires that the query must always have a bounding box defined. This can be presented as a BBOX –parameter of a GET query, or as a <fes:BBOX> -element inside either the FILTER –parameter of a GET query or inside the <Filter> -element of a POST query. If there are several <Query> -elements in a single POST type GetFeature request, they have to contain the same <fes:BBOX> value.

The Coordinate Reference Systems (CRSs) that are supported by the Cascading WFS include Web Mercator (EPSG:3857 or EPSG:900913), WGS84 (EPSG:4326), ETRS89 (EPSG:4258) and Lambert Equal Area (EPSG:3035). Whether a given CRS is supported by the backend national level service, varies from country to country.

The GetCapabilities response message of the ELF Cascading WFS is based on dynamic GetCapabilities –queries run on the backend national services. This way the GetCapabilities response of the Cascading WFS will better reflect the real status of the backend services. However, there are certain limitations. The GetCapabilities response defines the spatial extent of each feature type only by one single rectangle. As the spatial extents of the backend services are typically distinct, the extent definitions in the GetCapabilities response of the Cascading WFS soon become misleading. Because the other parameters, like the list of supported CRSs, must be defined as the greatest common denominator, some capabilities of the backend services remain hidden from the client application.

The COUNT –parameter affects each background service individually. For instance, if COUNT has a value of 1000 and the request is cross-border involving two countries, the maximum number of resulting features is 2000. If a sorting operation is requested, the result of each background service is sorted individually. The order of the response datasets inside the combined result is arbitrary (the responses are returned in the order they become ready).

ELF Cascading WFS supports only the following WFS 2.0.0 requests: GetCapabilities, DescribeFeatureType and GetFeature. In the case of the GetFeature request, ELF Cascading WFS does not support the FEATUREID –type query.

Feature identifiers must be globally unique for the Cascading WFS to work. In the case of the INSPIRE feature identifiers, this is handled properly by using a well-defined namespace mechanism. Some of the ELF national services already use feature identifiers with URI-based namespace prefixes, which automatically ascertains global uniqueness. However, this becomes crucial in the case of the XML ID-typed attributes used in geometry elements. These values must also be kept unique in the content aggregation phase, for instance by prepending them with the namespace prefix, or by some other mechanisms.

V. CONCLUSION

Real-time content aggregation that is tested in the ELF project is based on the principle of Cascading WFS. ELF Cascading WFS does not support the full-fledged WFS service interface specification. It has certain significant restrictions, like the fact that the query must always contain a bounding box.

A content request coming from a client application is first analyzed by the Cascading WFS to determine, which national level services must be included into the process. Then the request is forwarded to the involved national services, the resulting datasets are merged together, and finally returned back to the calling application. The analysis on the service inclusion is based on the bounding box of the query and on the requested feature types. The bounding box is overlaid on top of the dataset of national borders to determine, which countries the query overlap. The actual service on the country level is then selected, depending on the requested feature type.

Altogether 83 national download services from 13 different countries have been connected to the ELF Cascading WFS. These services provide access to over 120 feature types from 11 INSPIRE themes.

It can be said that the discussed research goals of the project have been reached, as the ELF Cascading WFS can be said to be being functionally ready. However, a lot of

 ISBN: 978-1-61208-539-5

work remains to be done to extend the spatial coverage of the served data sets and further improve their compatibility, for instance in the area of edge matching.

The ELF project has ended in Oct 2016. The service infrastructure is being maintained and even extended over the two years' transition period by the ELF participant organisations. More countries and services will be added and the quality of the data content be improved. After the transition period, the service infrastructure is going to be handed over to an operator that will maintain the ELF service platform on behalf of the EuroGeographics and the involved NMCAs.

The development of the ELF Cascading WFS service will also continue. New joining services must be configured into the service and tested. More rigorous testing of the ELF Cascading WFS itself, as it concerns both functionality and performance, will also continue.

ACKNOWLEDGMENT

The ELF project has been funded by the European Commission, Grant Agreement No 325140.

REFERENCES

[1] European Commission, INSPIRE Directive. http://eur-lex.europa.eu /LexUriServ/LexUriServ.do?uri=OJ:L:2007:108:0001:0014:EN:PDF Accessed 17 Nov 2016

[2] European Commission, COMMISSION REGULATION (EC) No 976/2009 of 19 October 2009 implementing Directive 2007/2/EC of the European Parliament and of the Council as regards the Network Services. http://eur-lex.europa.eu/legal-content/EN/TXT/PDF/?uri=CELEX:02009R0976-20101228&from=EN. Accessed 17 Nov 2016

[3] EuroGeographics, Home Page. http://www.eurogeographics.org Accessed 17 Nov 2016

[4] European Location Framework, Project Home Page. http://www.elfproject.eu Accessed 17 Nov 2016

[5] L. Lehto, P. Latvala and J. Kähkönen, Service Cascade as a Means for Pan-European Access to National Geodata Content CASE: European Location Framework. The Sixth International Conference on Advanced Geographic Information Systems, Applications and Services, "GEOProcessing 2014", Mar 23 – 27, 2014, Barcelona, Spain, CD-ROM.

[6] P. A. Vretanos [ed.], OpenGIS Web Feature Service 2.0 Interface Standard. http://portal.opengeospatial.org /files/?artifact_id=39967 Accessed 17 Nov 2016

[7] Open Geospatial Consortium, Home page. http//www.opengeospatial.org Accessed 17 Nov 2016

[8] Y. Deng and Q. Wu, Research on the harvest and cascade of catalogue service in GeoGlobe Service Platform. Proc. 18th International Conference on Geoinformatics: GIScience in Change (Geoinformatics 2010) Peking University, Beijing, China, June, 18-20, 2010

[9] J. de la Beaujardiere [ed.], OpenGIS Web Map Server Implementation Specification. http://portal.opengeospatial.org/files/?artifact_id=14416 Accessed 17 Nov 2016

[10] Simple API for XML, Home Page. http://www.saxproject.org Accessed 17 Nov 2016

[11] QGIS, Home Page. http://www.qgis.org/en/site/ Accessed 17 Nov 2016

[12] Oskari Platform, Home Page. http://oskari.org Accessed 17 Nov 2016

 ISBN: 978-1-61208-539-5