REAL-TIME CONTENT TRANSFORMATIONS IN THE EUROPEAN SPATIAL DATA INFRASTRUCTURE

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Abstract

European Spatial Data Infrastructure (ESDI) is currently under active development. One of the most important drivers is INSPIRE (Infrastructure for Spatial Information in Europe) that aims at building the European level geospatial content services on top of the existing national SDIs. The concept of Transformation Service has been raised as a possible solution for reconciling the differences that exist between data capture, representation and maintenance conventions adopted on the NSDI level. The categories of transformations identified in the INSPIRE process include coordinate transformation and data model transformation. Various approaches can be identified to integrate a transformation process into the service infrastructure. These are being investigated in a major EU research project called ESDIN.

Introduction

Seamless provision of basic geospatial information is a necessity in the increasingly integrated Europe. Especially the challenges related to the protection of environment emphasize the need to provide access to geospatial information consistently across the European borders. The long history of national independence in Europe has contributed to the fact that each Member State (MS) of the European Union (EU) applies rather individual approaches as it regards collection, organisation and maintenance of geographic information. The challenge of integrating these heterogeneous sources of information as a reliable and consistent information service has been tackled by various Pan-European projects and initiatives, aimed at supporting the development of the European Spatial Data Infrastructure (ESDI).

The ESDI is currently under very active development. Various research programmes of the European Commission (EC) have included actions aimed at building components for this infrastructure. One of the most important drivers in this development is the INSPIRE (Infrastructure for Spatial Information in Europe) initiative. The INSPIRE process is initiated by the EC and aims at seamless Pan-European spatial data provision in support of the protection of the environment (INSPIRE 2009a).

A fundamental principle of the INSPIRE process is to base the European level geospatial content services on the existing National SDIs (NSDI), without explicitly requiring changes on the Member State datasets. The diversity of the solutions adopted

by the European NSDIs makes this approach particularly challenging. One proposed answer to this challenge is to aim at data consistency through real-time transformations on service level. For this purpose a special network service category, the INSPIRE Transformation Service, has been identified.

In this paper the concept of Transformation Service is first described. The work carried out in the INSPIRE process to define a standardised access interface for this service type is then explained. The challenges related to the task of combining services are further elaborated on. Then some details are given about an experimental test implementation of the INSPIRE Coordinate Transformation Service, developed at the Finnish Geodetic Institute (FGI). The paper also introduces a major European project that focuses on content transformations in the ESDI context. Finally conclusions are driven and some steps for further work are identified.

INSPIRE Transformation Service

The task of the INSPIRE Transformation Service is to act as a mediator between the national data provider and a client application expecting geospatial content in conformance with the common European level data specifications. There are various aspects that need to be taken into account when considering this kind of content transformation. These include, for instance, differences in applied Coordinate Reference Systems (CRS), data modelling approaches, map visualisation cultures, natural languages, content resolution levels etc. The ultimate objective of the envisioned Transformation Service approach is to let the NSDIs to continue in serving the national causes and needs without disruption, and at the same time build the ESDI on top of this existing infrastructure as a service layer supported by content transformations.

The INSPIRE service categories and their technical access interfaces are being defined by a special international working group of national experts, the INSPIRE Drafting Team on Network Services (DT NS). The group has worked over two years to specify the service types identified in the INSPIRE base document, a Directive of the European Parliament and Council (EC 2007). These service categories include Discovery Service, View Service, Download Service, Transformation Service and Invoke Service (INSPIRE 2008a).

The approach taken in the case of the Transformation Service is to define the service first at an abstract level establishing the common concepts and functions applicable to all kinds of transformation processes. Then individual concrete transformation types can be defined that implement the identified abstract functions for the given transformation task. Two transformation categories are identified in the conceptual level document: coordinate transformation and data model transformation (INSPIRE 2008b).

The main principles and functions of the abstract Transformation Service have been defined by the DT NS and, based on this, the technical properties of the first concrete transformation type, Coordinate Transformation Service (INSPIRE 2009b) have been detailed. A process has also been initiated by the EC to develop the corresponding technical specification for the Data Model Transformation Service.

The service interface of the Coordinate Transformation Service is largely based on the existing international standards; it is defined as a Web Processing Service (WPS) Application Profile (AP) that derives its main principles from the Web Coordinate Transformation Service (WCTS) specification. Both of the base standards originate from the Open Geospatial Consortium (Schut 2007, Whiteside et al. 2007).

Combining Services

According to the INSPIRE Directive a Transformation Service is supposed to be 'combined with the other services ... in such a way as to enable all those services to be operated in conformity with the implementing rules provided for in Article 7(1)' (INSPIRE 2007). The reference to the Article 7, 'Interoperability of spatial data sets and services', of the Directive indicates that the main objective of the Transformation Service is to make national level data sets conformant with the European level INSPIRE data specifications. Consequently, the main service category with which the Transformation Service is to be combined with is the Download Service (service type that provides access to data content).

The connection between a Download Service and a Transformation Service is depicted in the following illustrations. In this discussion the Download Service is assumed to be of type INSPIRE Direct Access Download Service. A Direct Access Download Service is expected to accept a detailed query sentence as an input and be able to return a subset of its data content satisfying the conditions of the query. In this scenario the Transformation Service is actually faced with the challenge of a two-way transformation. The incoming query has to be first transformed from the European level form into the national form and, subsequently, the data content from the national form to the European form (the term 'form' here applies to all properties of geospatial data that change by context, typically including things like the used CRS or the applied data modelling constructs).

In the Figure 1 the connection between the two service types is illustrated as being orchestrated by the INSPIRE client application. The application would first request the query transformation to be performed by the Transformation Service. The transformed query is then sent to the Download Service and the resulting data content is received by the application. Finally, the data set is sent to the Transformation Service for processing.

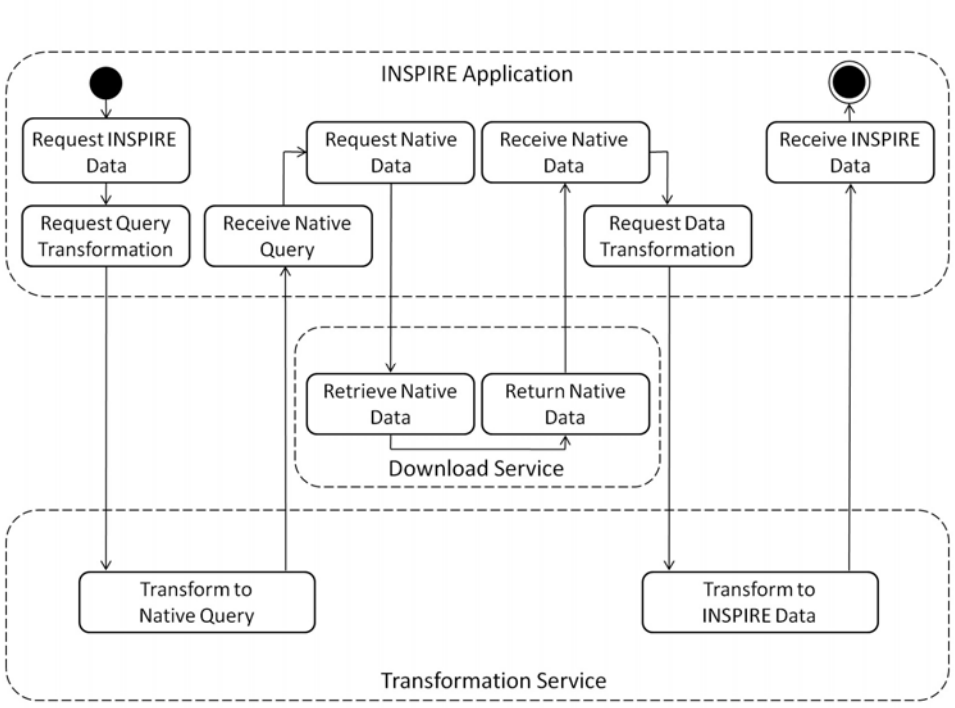

Figure 1. Combining a Transformation Service with a Direct Access Download Service. The process depicted as controlled by the calling INSPIRE application.

In the Figure 2 the same service combination is depicted. However, in this case a slightly simplified situation is assumed. If the initial call to the Transformation Service by the INSPIRE application includes the input data as a query reference to the Download Service, then the Transformation Service can proceed by first transforming the query and then requesting the data content directly from the Download Service. Subsequently the Transformation Service can process the received data set and return the resulting transformed data set back to the application. This arrangement reduces significantly the network transmission and makes the transaction much faster. However, from the point of view of the security and access control management the architecture becomes more challenging.

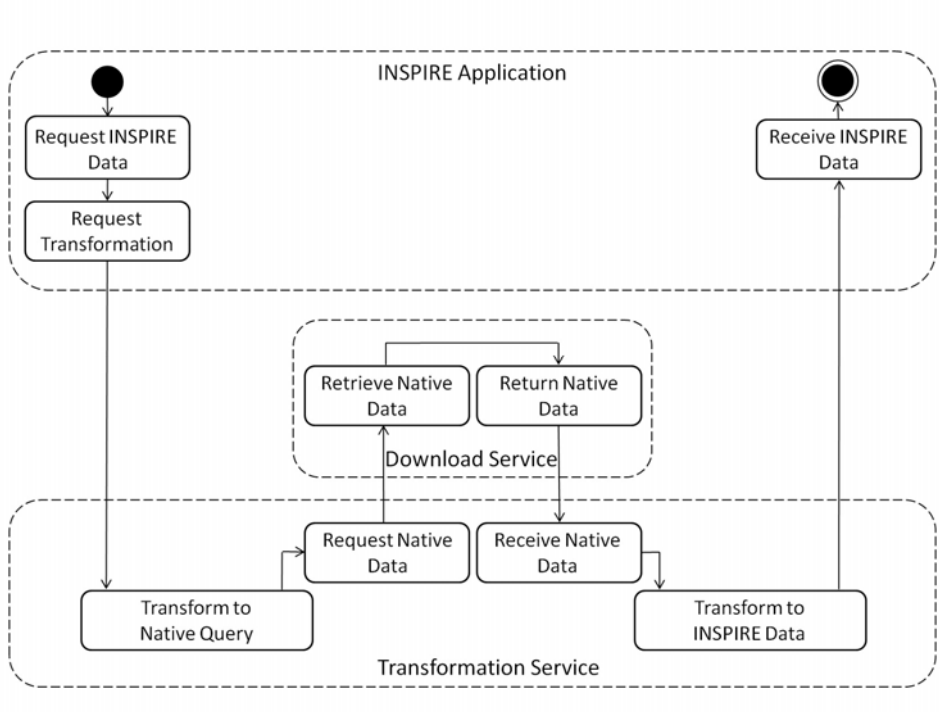

Figure 2. Combining a Transformation Service with a Direct Access Download Service. The process depicted as controlled by the calling INSPIRE application. Input data given as a query reference to the Download Service.

A third alternative for combining the two services is to assume that Download Service takes the responsibility of the call to the Transformation Service. This alternative is depicted in Figure 3. In this case the transformation process is performed behind the scenes; the calling application is not aware that a transformation is involved in the request. This approach makes the Transformation Service conceptually somewhat different from the other service categories that, according to the INSPIRE Network Services Architecture, are expected to be visible and accessible to the INSPIRE applications and portals. However, for practical service implementation reasons this alternative has to be considered. The benefits include for instance the fact that no modifications are needed in the client application to access Download Service, whether the transformation process is involved or not. The service orchestration is also more robust as the calling application cannot dynamically affect it.

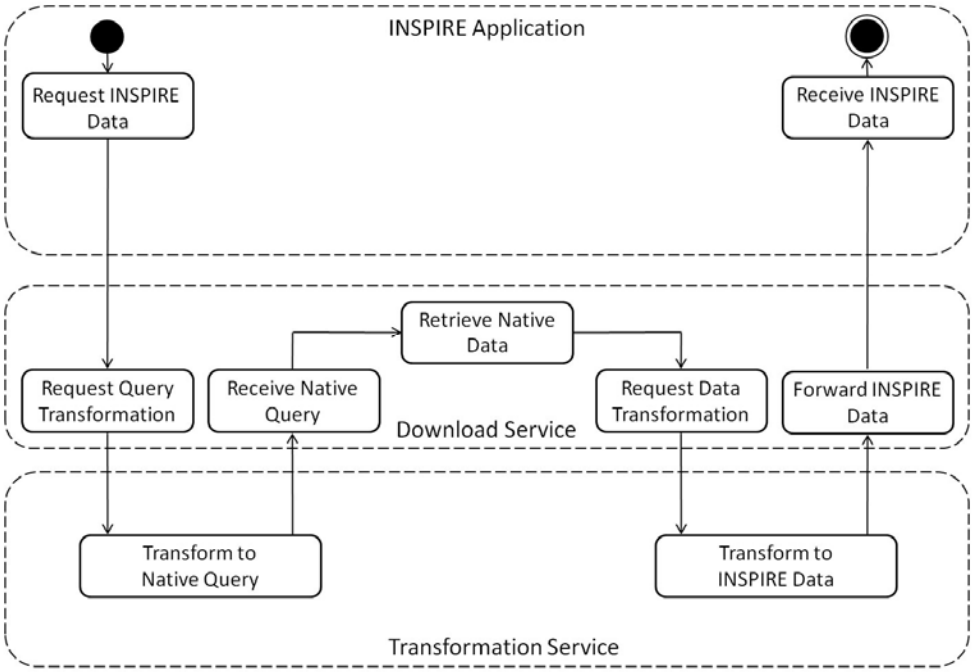

Figure 3. Combining a Transformation Service with a Direct Access Download Service. The process depicted as controlled by the Download Service.

Test Implementation of the FGI

A test implementation of the INSPIRE Coordinate Transformation Service has been developed by the Finnish Geodetic Institute (FGI). The initial results show that the use of a generic geospatial processing service (WPS) as the basis for the transformation service interface yields significant benefits by improving code reuse and facilitating service integration.

There are various Open Source implementations available that support the generic functionality of the WPS specification. The WPS implementation of the 52˚North community was used in the software development at the FGI, together with the CRS-related functions provided by the GeoTools-library (52N 2009, GeoTools 2009). The use of a generic processing interface also yields additional benefits, as some existing client applications, like uDig (User-Friendly Desktop Internet GIS), already support this interface and can thus be easily adapted to make use of service-side coordinate transformations (uDig 2009).

The tests carried out show that a single service node can process approximately 1 MB of Geography Markup Language (GML) –encoded input data per second, when the transformation involves a relatively simple taks, like a Transverse Mercator projection

from geographical coordinates to plane coordinates (ISO 2007). These performance figures seem to satisfy the Quality of Service requirements set by the INSPIRE service rules. The test implementation does not yet support query transformations.

A European CASE Study

Some European projects, like ESDIN (European Spatial Data Infrastructure Network), are starting to implement INSPIRE Transformation Services in concrete terms (ESDIN 2009). This project has as a general goal to investigate various approaches to content transformations in the INSPIRE context. The main interest of the project is focused on real-time transformations, predominantly in connection of data download (INSPIRE Download Services). The project consortium includes 11 National Mapping or Cadastral Agencies (NMCAs) from the same number of European countries, together with a few research organisations and private companies. ESDIN is a 2.5 year project with a total budget of 3.9 M€ and forms part of the eContentPlus programme of the EU.

The project has now been running for one year. The work related to the service infrastructure has started with an analysis on the prospective architectural solutions for the content transformation. The possible architectural alternatives identified in the project so far include transformations carried out on database level, internally by the Download Service, by a middleware gateway (a cascading type Download Service, a portal, a Transformation Service, a specific content aggregator service), or by the calling application (Figure 4). Various alternatives will be experimented with in the project and best practices derived as recommendations for organisations that need to provide INSPIRE-conformant data from the national content resources maintained at the MS level. These experiments serve as the first test for the approach and thus deserve to be carefully examined.

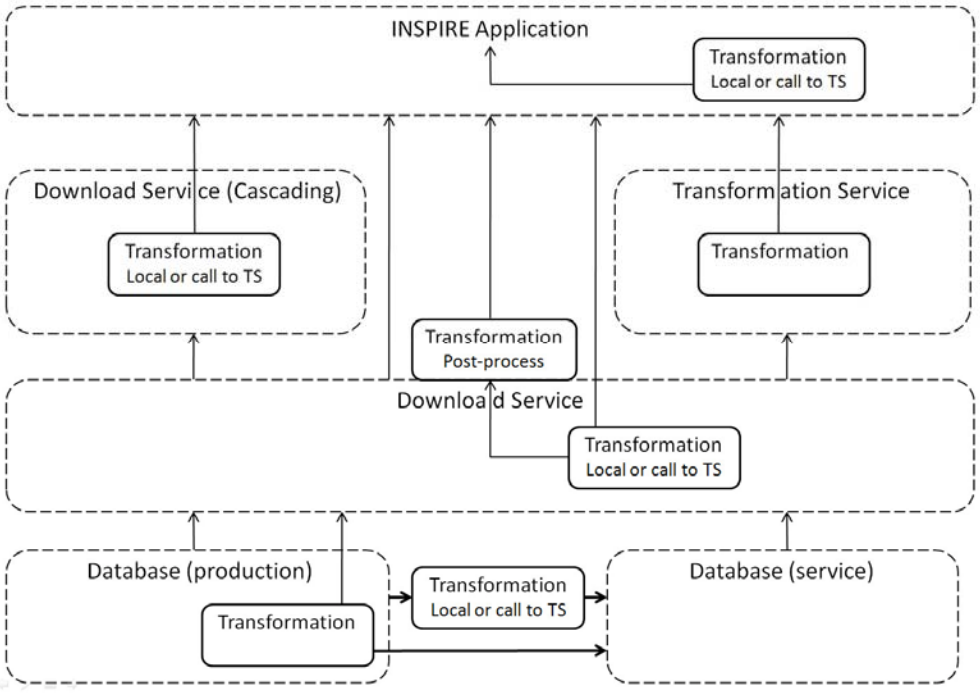

Figure 4. Architectural alternatives for integrating content transformation into the service infrastructure. Off-line processes depicted with bold line.

Conclusions

The concept of Transformation Service is potentially an important facilitator in the process of building a bigger SDI on top of the already existing lower level SDIs. It could be used in the regional context, like in the European case of the INSPIRE process, or it might be adopted on the global level by the initiatives that aim at building the Global Spatial Data Infrastructure (GSDI).

The standardisation efforts in the context of the INSPIRE process have yielded a specification for the access interface of the Transformation Service. Integration of the Transformation Service with other service types and with client applications is facilitated by adopting a generic geospatial processing service interface for the purpose. First concrete implementations of this specification focus on coordinate transformations.

From the point of view of user-friendliness it is important that all auxiliary processes be transparently integrated into the query transaction, so that the end user does not need to be concerned with them. There are various architectural ways to integrate content transformations into the process flow. These are being investigated in an EU project

called ESDIN. The initial results show that European NMCAs are going to base their transformation solutions on a variety of approaches, depending on the local conditions and needs.

The items for further work on the topic include the peculiarities related to the data model transformation process, like categorisation of transformation functions and an investigation on a language to encode the transformation instructions in a platform-independent way. Another important area for continued research relates to the query transformation. The issues to be clarified include the inherent limitations of the query transformation process and the relationship between a query transformation and the respective content transformation.

References

52N (2009), 52° North Initiative for Geospatial Open Source Software GmbH, at: http://52north.org [accessed 10 July 2009].

EC (2007). DIRECTIVE 2007/2/EC OF THE EUROPEAN PARLIAMENT AND OF THE COUNCIL of 14 March 2007 establishing an Infrastructure for Spatial Information in the European Community (INSPIRE), at: http://eur-lex.europa.eu/JOHtml.do?uri=OJ:L:2007:108:SOM:EN:HTML [accessed 10 July 2009].

ESDIN (2009). European Spatial Data Infrastructure Network, Project Home Page, at: http://www.esdin.eu [accessed 10 July 2009]

GeoTools (2009). GeoTools. The open source Java GIS toolkit, at: http://geotools.codehaus.org [accessed 10 July 2009].

INSPIRE (2008a). INSPIRE Network Services Architecture, version 3.0, draf, at: http://inspire.jrc.ec.europa.eu/implementingRulesDocs_ns.cfm [accessed 10 July 2009].

INSPIRE (2008b). Draft Implementation Rules for INSPIRE Transformation Services, Network Services Drafting Team, version 2008-10-31, at: http://inspire.jrc.ec.europa.eu/implementingRulesDocs_ns.cfm [accessed 10 July 2009].

INSPIRE (2009a). Infrastructure for Spatial Information in Europe, Home Page, at: http://inspire.jrc.ec.europa.eu [accessed 10 July, 2009]

INSPIRE (2009b). Draft Technical Guidance for INSPIRE Coordinate Transformation Services, Network Services Drafting Team, version 2009-02-10, at: http://inspire.jrc.ec.europa.eu/implementingRulesDocs_ns.cfm [accessed 10 July 2009].

ISO (2007). ISO 19136:2007 Geographic information - Geography Markup Language (GML).

Schut, P. (Ed.) (2007). OpenGIS® Web Processing Service, OpenGIS® Standard, Version 1.0.0, OGC 05-007r7, at: http://www.opengeospatial.org/standards/wps [accessed 10 July 2009].

uDig (2009), User-friendly Desktop Internet GIS, at: http://udig.refractions.net [accessed 10 July 2009]

Whiteside, A., Müller, M., Fellah, S. and F. Warmerdam (Eds.) (2007). Web Coordinate Transformation Service (WCTS) Interface Engineering Report. OGC Discussion Paper, Version 0.4.0, OGC 07-055r1, at: http://www.opengeospatial.org/standards/dp [accessed 10 July 2009].