Geospatial Content Services in the Digital Government

CASE: National Data Exchange Layer in the Finnish National Architecture for Digital Services

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***Abstract*—The long tradition of interoperability solutions for geospatial services appears as a challenge when new standards are taken into use in the general eGovernment development. Well-established geospatial service standards have to be adapted to the methods applied in public sector digital services. Issues related to this new integration challenge are discussed in the context of the newly introduced Finnish governmental service interoperability solution called National Data Exchange Layer. A project was initiated to investigate, how existing INSPIRE-compliant content services could be connected to this interoperability framework. Results of the pilot project indicate that in addition to the increased development burden and degraded service performance, there are also opportunities for luring new users to spatial data resources.**

Keywords-interoperability; eGovernment; data exchange; Web Services.

I. INTRODUCTION

Governments all over Europe are developing digitalized online services for their citizens [1]. The services being developed cover functionalities like taxation, applying for social benefits or a construction permit, seeking employment or checking one's retirement allowance. As more and more services are being introduced, it has become obvious that some coordination and standardization is definitely needed. Governments have initiated programs aiming at development of guidelines and policies that would improve the services interoperability. Common software modules are developed in a coordinated way to be shared among the services. Common content vocabularies and data schemas are being introduced in various sectors of public administration. Research efforts in this area include for instance the work of Dias and Rafael [2] to define open interoperability architecture for eGovernment services and Park et al. [3] to introduce a metadata standard for public Web resources on national level.

In the spatial data domain, standardization activities have already a long history. The work of Open Geospatial Consortium (OGC) and ISO Technical Committee 211, Geographic Information, are widely known and highly respected. The recent upsurge of openness, as exemplified in open standards, open data and open source software movements, has boosted the development of interoperable, network-based solutions for applications dealing with geospatial content. Spatial Data Infrastructures (SDIs) have been taken into use in several European countries. On the Pan-European level, initiatives like the INSPIRE Directive [4] are promoting the use of commonly agreed principles in the development of geospatial services.

When the new eGovernment services get widely deployed and agencies start to apply common, standardized approaches in their service development programs, a new question arises: how these developments relate to the existing, already well-established SDI platforms? Could the spatial data community affect the way the new eGovernment service standards are written? Is the spatial dimension taken into account in the generic online citizen services? If yes, is it done following the already defined spatial domain standards or do the spatial domain actors just need to adapt their existing services to the principles established in the eGovernment standardization? These are some of the new questions facing geospatial communities in many European countries. In this paper, the issue is discussed in the context of a recently introduced Finnish eGovernment interoperability framework, called the National Data Exchange Layer (NDEL) [5] and a development project with a goal to connect existing INSPIRE-compliant geodata services to this framework.

The rest of this paper is organized as follows. Section II describes some of the most important eGovernment standardization initiatives and their relation to the existing SDIs. Section III introduces the Finnish governmental program aimed at streamlining the development of digital citizen services. Section IV describes a pilot project testing the connection between the existing national SDI and the new generic approach for service development. As the conclusion, Section V details the main lessons learned in the pilot project.

II. EGOVERNMENT INTEROPERABILITY INITIATIVES

The European Interoperability Framework (EIF) is an important Pan-European initiative for facilitating the eGovernment service provision across country borders [6]. The EIF recommendations stress the importance of adopting open standards and jointly agreed dictionaries and data

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structures in the development of public online services. It also points out that the focus in the service development should be on ensuring security and user-friendliness. The traditional Web Services Publish-Find-Bind pattern is supported in the EIF specifications, facilitated by a Service Registry component. EIF also points out that the cornerstone for reliable eGovernment service provision is the establishment of mechanisms for signed, certified, encrypted and logged data transport over various different networks.

According to the INSPIRE Network Services Architecture [7], the EIF has similarities with the designed INSPIRE service platform. The EIF initiative aims at the development of the so-called PEGSs (Pan-European eGovernment Services) that are based on interoperable national level services. INSPIRE is based on the same kind of architectural approach. However, INSPIRE does not focus on Publish-Find-Bind pattern, nor does it define anything concerning the data transmission mechanisms. According to the INSPIRE Network Services Architecture document, INSPIRE services must be adapted to the EIF-specified communication platform in the long run.

The latest of the European eGovernment interoperability initiatives is the ISA Programme (Interoperability Solutions for European Public Administrations) [8]. The main objective of the ISA Programme is to improve cross-border and cross-sector interoperability of the national eGovernment services to create the digital single market for the EU. The new ISA^2 Programme will run from 2016 to 2020 as a follow-up of the original ISA.

In the context of ISA, there are actions that aim at bridging the gap between traditional spatial data community standards and the eGovernment interoperability solutions. They include projects like ARE3NA (A Reusable INSPIRE Reference Platform) [9] and EULF (European Union Location Framework) [10]. One of the objectives of the ARE3NA project is to facilitate reuse of INSPIRE-specified methods for interoperability outside the traditional geospatial community. ARE3NA has worked in areas like provision of geospatial data resources as Linked Data, and use of Persistent Identifiers (PIDs) to ease the use of spatial datasets as a location reference platform. The EULF project aims at increasing the use of location information in the eGovernment services and promoting the use of INSPIRE principles in new thematic areas, like transport, marine and energy. EULF will also create guidance on how to implement location enabled eGovernment services, and contribute to the further development of the EIF.

III. FINNISH EGOVERNMENT INTEROPERABILITY

A. Backround

The Finnish Government has started a large cross-sectorial programme, called National Architecture for Digital Services, for coordinated development of public sector online services [11]. The initiative is divided in four main areas of work: 1. Setting up a common data exchange mechanism (NDEL), 2. Developing user interfaces to government services for citizens, businesses and civil servants, 3. Enabling a common solution for secure authentication and single-sign-on in digital public services, 4. Creating a centralized solution for the management of user roles and authorization.

To establish a common data exchange platform for the public sector services, the Finnish Government made an agreement with its Estonian counterpart on the use of the Estonian X-Road platform for the purpose [12]. X-Road has been developed since 2001 in Estonia as the national solution for public services interoperability. At the moment it is used to access more than 2000 services providing access to 170 different databases. X-Road is used by half of the Estonian population, and close to 300 million requests is made over it annually.

B. XRoad Platform

X-Road is a decentralized communication and data transfer platform based on the Web Services processing model. The connections over the X-Road platform are facilitated by a special software component, called the X-Road Security Server. These components actually are running on a dedicated server hardware that is strictly defined, to ensure the highest possible level of security for the platform. Information systems always communicate with each other via two Security Servers (see Figure 1).

There is a centralized component in the system that maintains the routing information and is responsible for the centralized logging of transactions. However, Security Servers can operate independently of the Central Server, as they maintain a local copy of all the relevant information.

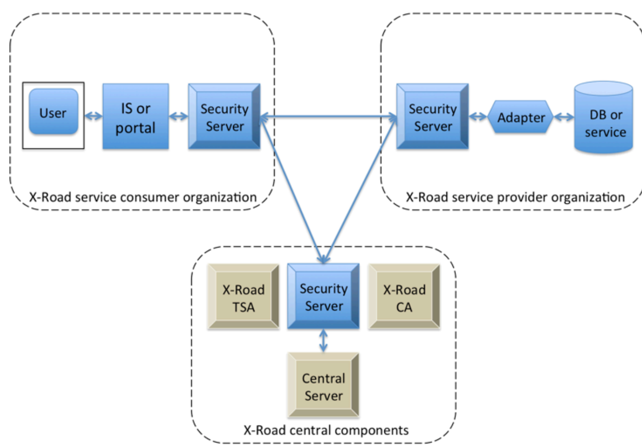

Figure 1. X-Road Architecture (CA: Certification Authority, TSA: Time Stamping Authority, IS: Information System).

The X-Road platform is based on traditional Web Services technologies. The communication is carried out using Simple Object Access Protocol (SOAP) messages [13]. The service interfaces are described using Web Services Description Language (WSDL) [14].

C. National Data Exchange Layer

In Finland, the Estonian X-Road platform has been taken into use mostly unmodified. The few Finnish additions include the so-called REST Gateway module, which facilitates the connection of traditional HTTP GET service interfaces to the X-Road's SOAP-based messaging platform. A software library has also been created to help the developers in building X-Road compatible services. The first operative version of the National Data Exchange Layer (NDEL) was launched in Nov 2015. A beta version of the first user application based on NDEL, the user interface for the citizen, was published in Dec 2015. As the first service, it provides access to the contents of the national Population Information System maintained by the Finnish Population Register Centre.

There are some plans to integrate spatial data and services to the NDEL and to the citizen's user interface. The first application would be a map user interface that displays locations of public sector service points on top of a topographic basemap, provided by the national mapping agency, National Land Survey of Finland (NLS). The second planned application would allow the citizen access to real property information from the Land Information System of Finland, maintained by the NLS. Reliable authentication of the user becomes a necessity in this context as the access will be restricted to the user's own property units.

IV. PILOT PROJECT

When the decision was made on the base technology to be used in the NDEL, it became necessary to test the connection between the already well-established National SDI and the X-Road platform. Over the recent years, the rapid expansion of the Finnish SDI has been mostly driven by the implementation efforts related to the INSPIRE Directive. Thus, a project was launched to investigate, how INSPIRE services, largely based on the OGC-specified interoperability standards, could best be connected to the NDEL [15]. The one and a half year project is funded by the Finnish Prime Minister's Office and coordinated by the Finnish Geospatial Research Institute (FGI). The project consortium includes several public sector organizations dealing with geospatial data.

A. *Use Case*

A use case scenario was developed, to build the pilot service development on a realistic context. The user story behind the scenario is a five-member family planning to buy or rent a cottage in the Eastern Finland North Karelia area. A mobile client application was developed for the iOS platform to demonstrate the use case (Figure 2). As a further aid to support exploring of the target location, a Differential GNSS (Global Navigation Satellite System) service, provided by the FGI and enabling sub-meter positioning accuracies, has been connected to the client application.

B. *Content Services*

All the organizations participating in the project provided a spatial data service to be connected to the pilot via the NDEL. The services offer various data sets that might be of interest when considering a target cottage and its neighborhoods. The services are listed below, ordered by the providing organization.

- The National Land Survey of Finland: Topographic Basemap (WMS), property information service from the Land Information System (WFS)
- Finnish Meteorological Institute: VIIRS (Visible Infrared Imaging Radiometer Suite) satellite imagery (WMS), average temperature from observation stations (WFS)
- Finnish Environmental Institute: lake water quality (WMS)
- Natural Resources Institute Finland: forest berry crop map (WMS)
- Geological Survey of Finland: surficial deposit map (WFS)

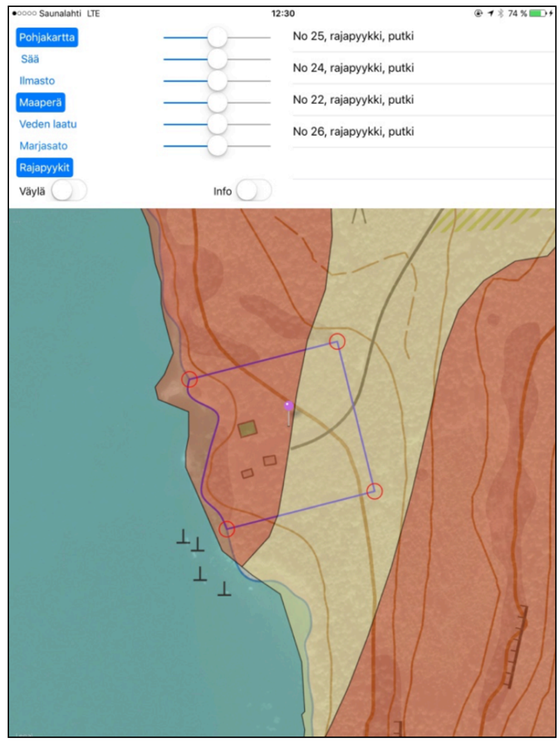

Figure 2. A map view from the mobile client application displaying a target cottage plot on top of the topographic basemap and the surficial deposit map.

C. *Adapter Services*

So-called Adapter Service is a crucial concept in the X-Road system architecture (see Figure 1). The task of an Adapter Service is to mediate between an existing information system and the messaging protocols of the X-Road platform. In the case of the OGC content services, like Web Map Service (WMS) and Web Feature Service (WFS), this involves unpacking the service request from inside the X-Road's SOAP messaging envelope and, subsequently, packing the resulting data set again into this envelope.

In the case of the POST WFS queries, the task of the OGC service Adapter is rather straightforward as both the POST queries and the resulting data set, in the default GML encoding, are expressed in the XML format. The Adapter Service has to simply retrieve the original XML structure

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from inside the X-Road SOAP message's XML envelope and, on return, embed the XML message back to the SOAP envelope.

The GET type WFS queries involve a bit more consideration. There are many different ways to encode the original query string to an XML element structure inside the SOAP envelope. The two extreme cases are: (1) The whole query string is packed inside a single XML element, (2) All query parameters are presented as individual strictly typed XML elements, possibly with carefully selected value enumerations and meaningful default values.

The corresponding POST-type query is an obvious candidate for modeling the XML structure. However, more strict schema can be specified for a given concrete service end point, thus making transactions more robust. Case (1) is easy to develop and fast to process. However, it does not reveal the details of the service interface in the WSDL service description. Case (2) is more complicated to build, but will ease the development of client side applications, as the WSDL can be used as the basis for automated code generation, and the exposed value enumerations and default values contribute to more reliable communications.

For the WMS service the situation is quite different. As only GET queries are widely supported, the model for the query encoding must be selected. However, there is no obvious candidate for this. One possible solution is to use the XML-encoded GetMap query defined in the Styled Layer Descriptor (SLD) specification.

In the case of the WMS result data set, which is normally a raster image, the processing task is more involved. Two main approaches are available: the image can be encoded and embedded inside the SOAP envelope's internal element structure or it can be sent immediately after the envelope, using mechanism called SOAP with attachments. For the embedded transmission, the image has to be encoded into text. The mostly used encoding scheme is Base64. When sent as an attachment, the image can be transmitted in binary format.

In the Finnish pilot project, the WFS messaging has so far been performed using the simplest possible approach: sending the whole query string inside a single XML element. In the case of the WMS Adapter Service, the request is sent inside a single XML element and the resulting map image as a SOAP with Attachments message.

If an existing OGC-compliant client application is used to make the request, an Adapter Service is also needed on the client side. In this case the NDEL works as secure, controlled data transfer channel, remaining completely hidden from the client and the service. This kind of architecture is shown in Figure 3. Initial tests carried out in the project show that NDEL used in this way incurs certain level of degradation in the query performance. In case of WFS, the query is 1.5 times slower compared with direct request over public Internet, whereas for WMS services this figure is approximately 2.5. The reason for slower response times is the additional processing required to encapsulate the original requests and responses into the SOAP envelope and, in case of the WMS map response, the process of transforming the map image into the Base64 encoding. Performance tests were carried out using the Apache JMeter testing tool.

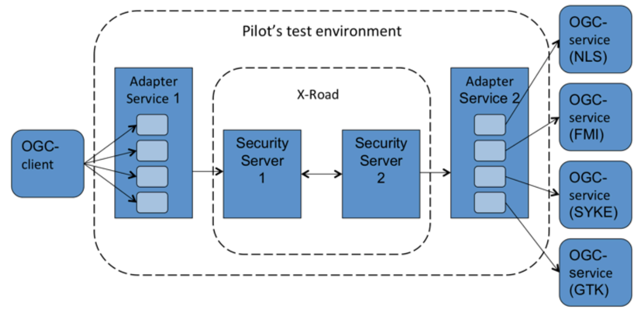

Figure 3. Service Architecture used in the pilot project.

D. New APIs

The service architecture depicted in Figure 3 represents the case, in which an OGC-compliant client application is used. However, introduction of NDEL actually opens access to traditional OGC services for a set of new client environments. These can be divided into two categories. Firstly, SOAP client code can be automatically generated based on the detailed service descriptions expressed in WSDL. Secondly, the NDEL concept of Adapter Service can be exploited to create a completely new category of service interfaces, for instance APIs adapted to the requirements of the modern Web applications programming model. These two new approaches are added to the service architecture model shown in Figure 4.

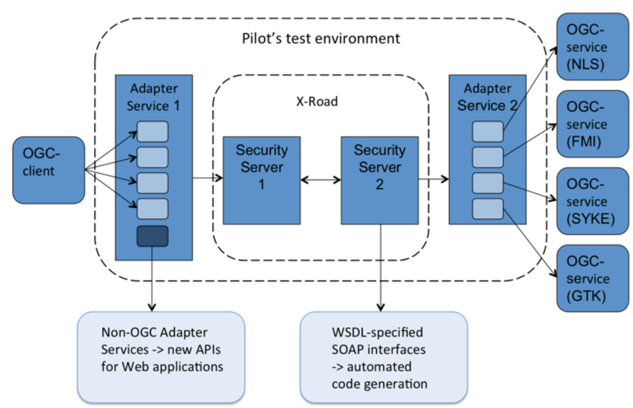

Figure 4. Service Architecture with two new access approaches added.

In the pilot project, the first implementations have been developed to test a new API for OGC services. This service interface is an attempt to provide the easiest possible access to both WMS and WFS interfaces. Geocoding functionality is embedded into the service interface, so that the client can use an address as the indicator of the queried location. The request is encoded as a REST query path. Most of the traditional query parameters can be left out. The service will use reasonable defaults for them.

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An example of a query to a WFS interface could thus be expressed as follows:

http://[service domain]/spatialobject/parcel/Helsinki/Mariankatu/23

In this query all parcel objects are requested from around the point into which the given address is geocoded. For all other relevant parameters reasonable defaults are used by the service. In case the defaults are not appropriate for the client, these can be given as further path components in an order specified in the API definition.

In a similar manner, one could request a map image with the following query:

http://[service domain]/map/basemap/Helsinki/Mariankatu/23

New user groups can be given access to geospatial data resources using easy-to-use APIs like these. In Finland this opportunity is opened by the Adapter Service concept present in the NDEL platform. Thus, the approach can be seen as a positive outcome of the NSDI – eGovernment services adaptation challenge.

V. CONCLUSIONS

The Finnish NDEL platform represents an example of the new eGovernment services interoperability development programs. Connection between the already well-established INSPIRE/OGC-compliant NSDI and the new NDEL platform has been tested in a pilot project.

The need to adapt the NSDI services to the general eGovernment services interoperability mechanisms can be seen as an unnecessary burden. The tests carried out in the Finnish pilot project confirm that running a query from an OGC-compliant client to an OGC-compliant service via the NDEL platform incurs a significant performance degradation. This means from 1.5 to 2.5 times longer query times, compared with queries that go directly over open Internet.

However, connecting the NSDI with the eGovernment service platform can also open new opportunities. In the case of the Finnish NDEL, these include for instance the possibility to utilize detailed service descriptions in WSDL for automatic code generation. Another positive example is the opportunity to lure new users for spatial data sets via new easy-to-use APIs that are based on the Adapter Service concept, present in the NDEL service architecture.

The future work of the pilot project include for instance more profound testing of detailed WSDL descriptions to support automatic code generation, and performance testing of alternative methods for encoding binary information into NDEL messages. The pilot service will also be connected to the national centralized authentication service to enable single-sign-on, thus fostering more tight integration with other Finnish eGovernment services.

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