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Use Case Driven Dynamic Integration of Cross-Domain Content

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Abstract:

Geospatial content services can typically be seen from two major perspectives: from the content provider's point of view or from the user's point of view. Most of the projects with the goal to develop and demonstrate services providing access to geospatial data resources have solved the task from the data provider's point of view. This is natural as the main actors of this kind of projects are usually content providers. Recently the focus has been gradually shifting towards the user- or use case-oriented approaches. A major EU-funded project, called Geospatially Enabled Ecosystem for Europe, GeoE3, has taken the needs of selected use cases as the basis for the service development and demonstrations.

One of the selected use cases of the GeoE3 project is renewable energy for buildings. The relevant aspects to consider include for instance potential of the building for solar energy acquisition, effect of local climate conditions for insulation, potential for wind energy etc. After careful analysis of the data needs of the use case, the following data sets were prioritised as being the most relevant: buildings, Digital Terrain Model (DTM), Digital Surface Model (DSM) and selected climate attributes. In particular, it was recognized that provision of 3D modelled buildings would be paramount for the success of the project. It was also noted early on that mechanisms for cross-domain data integration would be needed, as climate-related attributes were deemed necessary to satisfy the needs of the use case. Content from meteorological sources must be integrated to the geospatial features. Dynamic, service level approaches were deemed necessary for achieving this goal.

As the project is aiming at complete spatial coverage within the study region, the data resources of the National Mapping and Cadastral Agencies (NMCAs) from all participating countries are used as source data sets. The countries taking part in the project are Finland, Estonia, Norway, The Netherlands and Spain. Although the 3D content provision is just starting in most of the European NMCAs, the project has managed to make 3D buildings available from all of the member countries. Genuine LOD2 building models are available from part of Finland (Figure 1a), and the whole area of Estonia (Figure 1b) and The Netherlands (Figure 1c). For Norway (Figure 1e) and the missing parts of Finland, a dynamic on-the-fly process has been devised to construct LOD1 building models from the building's 2D footprint and the elevations derived from the DTM and DSM in the area of the building. In the case of Spain (Figure 1d), a LOD1 model representation is dynamically generated, based on the 2D footprint and the attribute indicating the number of the floors of the building. The 3D models are made available from the GeoE3 services encoded in the modern, light-weight 3D modelling language CityJSON.

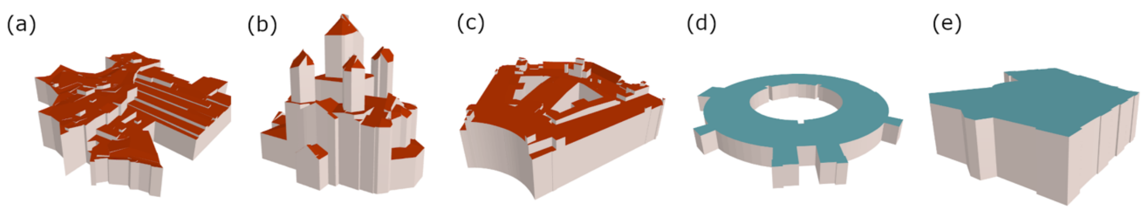

Figure 1. Examples of 3D buildings from (a) Finland (LOD2), (b) Estonia (LOD2), (c) The Netherlands (LOD2), (d) Spain (LOD1) and (e) Norway (LOD1).

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For on-the-fly data integration and harmonization, a specific cloud service-based computing platform has been developed. This GeoE3 Integration Platform provides single point access to harmonized content from all the participating countries via modern OGC API family of service interface standards. Content is accessed from the national level legacy services and the necessary transformations to the common form are carried out on-the-fly by the integration platform. These transformations include schema transformations, coordinate reference system transformations, access protocol transformations, unit conversions etc. For vector data provision, the OGC API Features and for raster data, the OGC API Coverages service interface is used on the integration platform. A Python-based OGC API implementation, pygeoapi, is used as the software basis for the integration platform. The offerings of the individual country-level services are treated as data collections inside a single OGC API Features or OGC API Coverages service instance. This arrangement establishes a novel approach for dynamic, service level content integration. Content integration across country borders is supported by the so called OGC API Features cross-collection query mechanism. GeoE3 Integration Platform also supports experimental cross-collection queries for the OGC API Coverages service.

Climate attributes have been accessed via APIs provided by the national meteorological agencies in Finland, Norway, Spain and the Netherlands. In all of the cases the attributes represent long period (30 years) average values. The meteorological APIs used do not follow any standardized protocol. Thus, a service-specific access module had to be developed for each of the APIs. The source data corresponding to observation points is converted to an interpolated grid representation on the platform and stored as a GeoTIFF image. Based on these images, the climate attributes are served via the OGC API Coverages service interface for each requested position. By this mechanism, all the available climate attributes: temperature, wind speed and sunshine hours, can be attached to individual building features. In addition, several use case-specific technical building attributes are accessed from external databases by ID-based queries and attached to the building by the platform. These include for instance an attribute indicating the building's energy class, where available.

GeoE3 Integration Platform thus supports renewable energy-related applications by providing easy and consistent access to 3D buildings, DTM, DSM and certain climate attributes across five European countries (Figure 2). The 3D building models, together with DTM and DSM, support analysis on the amount of sun exposure to the roof of a building, thus helping in evaluating its potential for solar panel installations. The analysis is further facilitated by the fact that climate attributes, like the average amount of sunshine hours per year, are readily available as properties of the building feature. Various technical attributes queried from external databases and attached to the building, like information about the heating system and heating fuel used in the building, enable further analysis on the energy efficiency, for instance of a given built-up area.

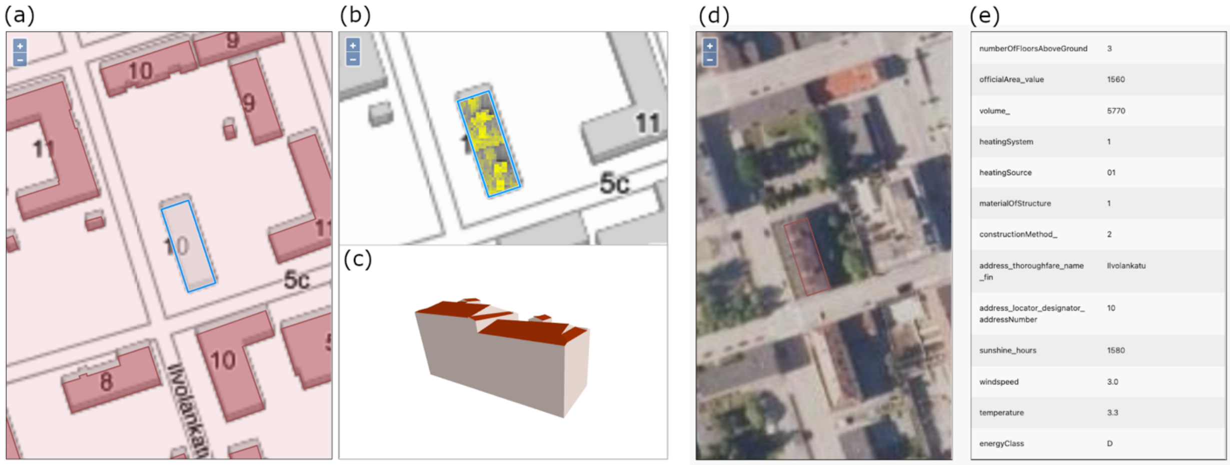

Figure 2. Exemplary GeoE3 application user interfaces. A building has been selected in the 2D map window (a). On-the-fly DSM-based analysis is run to determine the amount of sun exposure to the area of the building (b). An interactive 3D visualization of the building is also provided (c). The building is shown on top of an ortophoto background (d) and its attributes are displayed (e). The attributes include energy efficiency-related attributes, like 'heatingSystem', 'heatingSource' and renewable energy-related attributes, like the climate attributes: 'temperature', 'windspeed' and 'sunshine_hours'. The determined energy class of the building is also shown ('energyClass').

GeoE3 Integration Platform represents a novel approach for the use case specific provision of geospatial data. Additional properties, relevant for the use case, are dynamically retrieved from external databases and services by the platform and attached to the geospatial features as their local attributes. At the same time the platform integrates content offerings from

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five European countries as a set of harmonized data collections, accessible by consistent retrieval mechanisms, and following the modern international service interface standards. GeoE3 Integration Platform can thus be seen as an example of an optimal service provision approach for facilitating solutions to the energy crisis currently plaquing the whole Europe.

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