CO-029

AN INTELLIGENT GEOPORTAL FOR SPATIAL PLANNING

IWANIAK A.(1), KACZMAREK I.(1), KUBIK T.(2), ŁUKOWICZ J.(3), PALUSZYNSKI W.(2), KOURIE D.(4), COOPER A.(5), COETZEE S.(6)

(1) Wroclaw University of Environmental and Life Sciences, WROCLAW, POLAND ; (2) Wroclaw University of Technology, WROCLAW, POLAND ; (3) STRUKTURA - Spatial Planning, GIS, GDANSK, POLAND ; (4) Department Computer Science, University of Pretoria, PRETORIA, SOUTH AFRICA ; (5) Department Computer Science; Built Environment, CSIR, PRETORIA, SOUTH AFRICA ; (6) Department of Geography, Geoinformatics and Meteorology, University of Pretoria, PRETORIA, SOUTH AFRICA

INTRODUCTION

The main idea of the INSPIRE Directive [1], establishing an infrastructure for spatial information in Europe, is to remove barriers in using and sharing official spatial data by various groups of users (common, commercial, administrative) and avoid redundancy in the data sets. A side effect of the directive, which was originally oriented on establishing better conditions for the implementation of environmental strategy in the European Union, is an information and knowledge exchange between users with different backgrounds and interests.

From the technical point of view, the nodes of the information infrastructure are distinguishable, autonomous parts of the complex system built on the SOA (Service Oriented Architecture) paradigm. The nodes deliver services that can be combined according to particular needs and integrated on a service bus. A consumer of a service can be a human accessing services by running a web application, a human using an internet-enabled application, or a machine that connects to the service provider automatically while executing its own process. However, humans may experience accessing information difficult if the applications do not offer a user-friendly graphical user interface (GUI), which hides behind it all the details.

According to [2], development of spatial information infrastructures started with SDI 1.0 (data-centric spatial data infrastructure). Then it evolved into SDI 2.0 (service-centric spatial data infrastructure), and next into SDI 3.0 (user-centric spatial data infrastructure). Thus, the user-centric point of view focuses on how to build the solution that fulfills user needs, rather than on how the data are organized and structured.

The authors present the concept of an intelligent geoportal, which can be seen as a gateway to a spatial data infrastructure intended to fulfill the needs of any particular user by providing a user-friendly interface that hides behind it the details about different data sources and processing. In this paper the focus is on an intelligent geoportal for spatial planners. The proposed solution uses semantic technologies to support users' specific requirements.

THE ROLE OF SPATIAL PLANNING IN AN SDI

The aim of the SDI is to integrate spatial data from different fields that have a single common aspect – references to the surface of the Earth. These references allow one to establish spatial relationships between objects (also known as features). However, the simple observation and recording of phenomena is not sufficient for spatial planning. The aim is appropriate space management that increases positive influences and minimizes negative influences, in accordance with the sustainable development paradigm. This calls for the creation of an infrastructure that could become the foundation for decision support systems (such as expert systems) [8,9].

Assuming the information is interdisciplinary but complete, there is a huge amount of domain data to be dealt with. The planned infrastructure is complex. It covers multiple themes without which no decision process is possible. For prioritisation purposes, the mutual interactions, both logical and spatial, between objects in the data sets are important. For this reason INSPIRE is based on reference data that include: topographic, geodetic and cadastral databases. One of the goals of an SDI is to create a tool for the rational management of environmental resources. In this regard, the key resource integrating all the topics necessary to build appropriate decision support systems and expert systems is specified in the documents and materials of spatial planning.

Spatial planning creates a conceptual foundation for shaping the local area. It provides formal tools for determining the purpose of the land. Thus, the system of spatial planning is usually an element of the legal system and the formal planning documents are subject to specific legal regulations. The process of shaping space in accordance with sustainable development is specified in the spatial policies at different levels of management. In the case of Poland, these are a National Spatial Management Concept, Voivodship Spatial

Management Plans and Studies of Conditions and Directions of Spatial Development of Municipalities. The documents determining the zoning of an area or the location of an investment are articulated by local law. Because of this legal framework, such documents determine the legal status of real estate and specify the extent to which an owner is entitled to use land. In Poland these documents are called the local spatial development plans. None of the planning documents can be considered separately; they should always be interpreted with respect to more general planning documents as well as with respect to numerous distinct regulations.

According to Act on spatial planning and development [3], spatial planning is performed at the following administrative levels in Poland:

• country-wide – National Spatial Management Concept,

• regional – Voivodship Spatial Management Plans,

• county level – optional studies,

• local district

• Studies of Conditions and Directions of Spatial Development of Municipalities,

• local spatial development plans.

Every lower-level document must take into account the findings of a higher-level one. Every study must deal with a separate issue in accordance with the distinct regulations. Each one covers the social, economic and environmental issues relevant to its level and extent.

Spatial planning documents utilize an ever-evolving list of categories of spatial objects which have various sets of attributes at different levels. There may be complex spatial relations between them that cannot always be predicted in the model. This is not about the relations such as: a building is situated within the borders of a parcel; or the planning area can be located inside a restricted area of nature protection. Each of these relations translate into specific conclusions regarding the land. In addition, spatial planning must also consider the interdependence amongst objects. Some of them are determined by indicators, while others result from distinct regulations or documents such as the environmental impact studies. These dependencies form zones, for which a separate group of categories (i.e. a taxonomy for spatial planning) is needed. The objects of such a group are not always explicitly presented in a planning document, though they need to be included in administrative procedures. The majority of the recommendations in the planning documents are normative or legally binding regulations. Consequently, the attributes of particular objects are phrases written in natural language, i.e. text variables. Relatively few attributes are numerical, Boolean, enumerations or derived from a thesaurus. This dominance of free text is probably the most significant obstacle to the unification of planning documents.

WEB 3.0: FROM THE DATA, THROUGH INFORMATION, THE KNOWLEDGE

The development of information systems and technologies, along with the World Wide Web, deliver powerful data resources. The Web is the largest easily accessible database. However, access to its resources is still largely determined by search engines which return the best match for the typed phrases. Such a system is “human readable” rather than “machine readable”. This constitutes an obstacle to transforming it into a database running as an engine that is fully compliant to users' expectations information sharing system.

The Web 3.0 is based on a different philosophy from the currently dominant model of an information infrastructure. The metadata that describes an object must have a reference to a specific context. Furthermore, they should be situated within a particular logical structure, a hierarchy of concepts, and be linked to other concepts, the classes of objects from other domains. This is where the tools of Web 3.0 do the job: the ontologies that create the register for logical models of objects and their features, thesauri that group concepts according to semantic links between them, and finally graphs of logical connections according to the scheme of subject → predicate → object (RDF).

In Web 3.0, users may create their own ontologies, linking to the ontologies provided by web services, so that the information obtained can best reflect their expectations. [10]

Such a model is becoming useful for analyses, simulations and designs in various environmental, economic and social domains. This will allow for:

• Access to specific data, not only within a specified set, but with respect to the features that make them adequate for problem solving.

• Analyses using raw source data, whose products will be described by complex sets of features. These features would be aggregated with respect to location or to a class of simple objects that belong to multiple spatial domains.

• Capacity to operate in the languages preferred by unqualified users or representatives of different fields, who are not necessarily acquainted with the technical language(s) used in other sectors of spatial management (planners who analyze cartographic or infrastructural data; real estate agents who analyze geodetic, planning or transport data; etc.).

• Utilization of distributed data, shared over the web by the subject domains who manage them.

• Utilization of web services, data and metadata of a national infrastructure for spatial information, as well as the Web 3.0 technology.

THE DESIGN OF A INTELLIGENT GEOPORTAL FOR SPATIAL PLANNERS

The geoportal design presented here is dedicated to decision support in spatial planning. It should assist a human spatial planner who needs countless data in the planning process. Detailed and multifaceted information about the development of an area or parcel is needed for the planning work. Working out a set of methods for advanced data and metadata searching for spatial planning purposes could be the basis for defining standard analytical procedures for the domain.

The basic data used in the spatial planning process are contained in a geodetic and cartographic database. Having an appropriate data model for the geodetic and cartographic databases within the spatial planning domain, would permit systematic creation of analytic procedures for determining the current legal and actual status, formulating development scenarios, and exploring possible scenarios for the spatial policy being implemented. Describing the datasets and the objects contained therein with ontologies is the way to represent spatial knowledge.

The national geodetic and cartographic databases and the buildings and land registry maintained in Poland do not directly provide all the required information about parcels and their suitability for development. However, by combining the data about the administrative boundaries, parcel properties, and the land use, and their relations with development, such information could be derived by inference.

Presented below in Figure 1 is an example class hierarchy of the combined ontologies for spatial planning and geodesy.

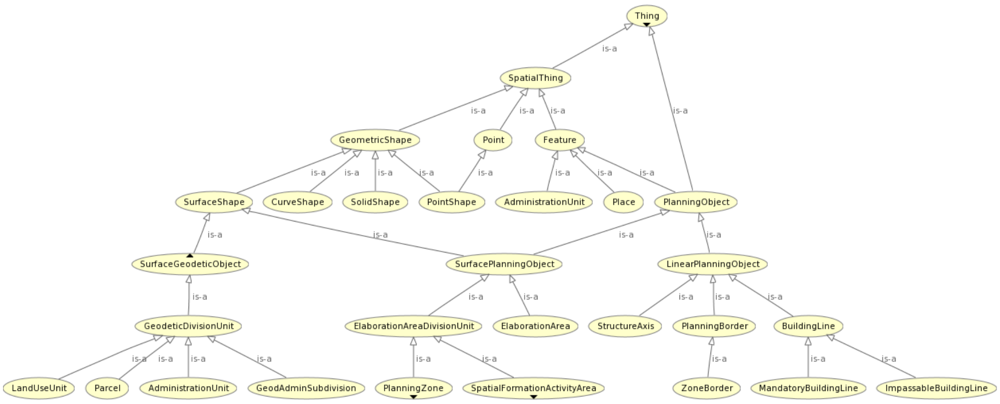

Figure 1: Fragment of graph which represents ontology for spatial planning and ontology for geodesy

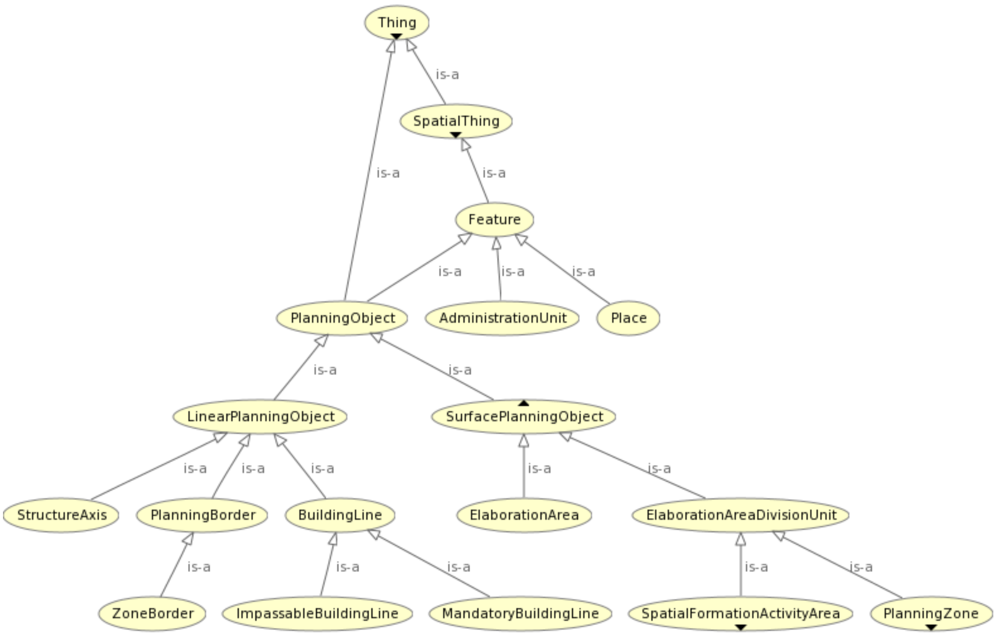

Figure 2: Fragment of the graph which represents ontology for spatial planning

The basis is the set of concepts defined in different ontologies, worked out by different teams, for the purpose of identifying spatial and geographical objects (wgs84_pos:SpatialThing [3], or gn:Feature [4]). Matching data to corresponding concepts works by describing subsequent data, providing them with attributes, which in turn receive values. Although not all properties and phenomena can be represented, typically the user, eg. the investor, working on her specific problem, does not need information about a million parcels from all of Poland, but a hundred selected from the local county would suffice for her, to select a few likely candidate parcels for personal inspection. The system does not require all the data to be complete, and works with incomplete or missing data. On the other hand, having access to unlimited distributed data compensates for some of the shortcomings of some sources.

Technically, the system flexibility is achieved by single users or their communities building specific ontologies, such as the above-mentioned GeoNames[4], DublinCore[6] or FOAF[7], which let them first describe and then interpret the data.

We assume that all information has been inserted into all the registers, as required by law. We also assume that there exists a controlled means of access to the data. These can be provided by dedicated network applications, web services, or data base interfaces, such as ODBC/JDBC. The data are limited to public data. A particular assessment technique for these data is another matter.

Example datasets in the national geodetic and cartographic databases are:

• The set of areas and buildings: precincts, parcels, buildings, premises, utility areas.

• GESUT (Surveying Records of Public Utilities): data about the types of links, such as: sewer, water, heating, gas, communications, electrical, or other, about the identifier and their attributes.

Taking as an example the area surrounding a large town, a private investor is looking for a real estate property connected to the utilities, accessible by public transport, and suitable for “residential development.” This term is taken from common language, but is sometimes defined narrowly in local plans. Firstly, the “residential development” would have to be rooted in the spatial planning conceptual structure, as a special case of extensive, single-family residential development (large parcels), with higher than average-sized houses. Next, the datasets containing local plans would have to be searched for planning areas that would be suitable for such a kind of “residential development”, even though these plans do not necessarily include such a category.

That is, before the system can identify the parcel, its geometric properties, public road access (reference to the road network), and utility connections (reference to the GESUT), must be verified.

The current data distribution system does not allow for automatically and systematically generating answers to such kind of questions. To analyze this problem a “human factor” would have to be involved – the persons professionally involved in geodesy, spatial planning, real estate markets, public utilities and transport management. Just the sheer number of concepts, often defined differently in different domains, can prohibit a layman from effectively solving the problem. But bringing in humans, however expert, would lead to error-laden or incomplete answers: it is hard to imagine efficiently analyzing many thousand of areas, containing hundreds of thousands of parcels from 30-40 communities).

CONCLUSIONS

The main purpose of the INSPIRE architecture and design is disseminating raw data, either geometric or descriptive. These data cannot be easily tailored for other purposes than the ones for which they have primarily been created. Every attempt to use the data, aggregate them or integrate them with data from other domains will require a thorough recognition of their inner structure, the model, or even the type of data in the case of particular values describing interesting objects.

Semantic networks and their associated tools allow for linking together phenomena and objects from different domains, without the need for a precise but sometimes implausible "mapping" of data structures. The nature of this linkage is logical or even semantic, but not functional or technical. The hierarchy of classes of objects allows one to follow the links of mutual dependencies to seek objects that have not been previously "mapped", even though their features and values indicate that such a connection might exist. This is the process of inference.

These techniques enable automation for finding solutions to many problems faced every day by investors, both regular citizens and professional developers; surveyors who design geodetic frameworks; planners who use cartographic data in the process of planning; real estate agents; realty assessors; environmental scientists; and others. These are the problems of:

1. calculating demographic indicators for any given area (e.g. population density, or demographic forecasts related to a specific purpose of the terrain),

2. estimating the habitation quality indicators or residential indicators (e.g. apartment area per inhabitant) and simulating the development needs with respect to demographic changes and predicted changes of standards,

3. analyzing the usefulness of an area for development along with the analyses of the necessary transformations regarding different development scenarios: whether there are construction parcels within a given area and what part of them may be used for construction according to the current law,

4. analyzing the changes in efficiency of land use under various rules for management (functions, size limits of the marked parcels, degree of development).

The concept of a planner-oriented geoportal, using ontologies and semantic networks, will lead to support the decision processes not only in spatial planning, but also in other domains in which spatial data constitute the key element in decision making.

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