Spatial Objects in the Domain Model of the Public Real Estate Administration System. Case study of the Geographic Information System for the Police's Real Estate Administration

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Key words: real estate, conceptual model, domain model, spatial object, UML, GIS

SUMMARY

Modern real estate management system is an element of integrated information system supporting not only the management of real estates but also human resources, wages, warehouse and transport systems, as well as fixed assets. Their standardization allows the exchange and integration of data among various organizing units, acknowledging the aspects of the economy at the same time.

The paper presents spatial objects of application schema of the administration system for the Police own real estate in relation to geographic information about those estates. Adapted approach allows to perform many different spatial and non-spatial analyses and to visualize the results of those. But the main purpose of the System is to provide more efficient and effective management of the Police's real estates, proved by the observable decrease of their maintenance costs and better identification of unprofitable entities.

The author of the paper, together with a team from Military University of Technology in Poland and ESRI Poland, works on a prototype of a real estate administration system for the Police's properties.

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1. BACKGROUND

In the last decade, while the GIS technology has been evolving rapidly, spatial data has been used in all fields of economy and administration. One of many possible applications of GIS is an application for the purposes of estate management. An effective and secure real estate administration system is essential for the welfare of a country's economy. Users at all levels require accurate and current land records for mapping the location and the extent of landholdings, establishing the ownership of rights in real property, and determining the value of those rights. What's more, a modern property management system should be interoperable with other systems, such as: mortgage, accounting system, public utility, fiscal cadastre, planning, warehouse and transport systems, etc. The basic condition for achieving interoperability is the use of the international standards, especially the conceptual modelling and UML language for describing models (Alhir 2003, Elmasari et al 2000, INSPIRE 2010, ISO 19101:2002). A conceptual model can precisely describe a universe of discourse with terms and concepts that are familiar to people who work in the domain of the problem, in a way that avoids delving into technological details.

Domain model for a public real estate administration system should include, inter alia, spatial objects that represent parcels and parcels' boundaries, buildings and apartments, as well as administration units, statistical units, address points, etc. All spatial objects have geometry (represented by points, lines or polygons), direct position registered in a Coordinate Reference System, topology showing spatial relation among objects, attributes and identifiers.

Commercially available systems to support real estate management processes are designed for different customers, from large shopping centers to individual buildings forming a housing community. Thus, their functionality also varies, from simple registration costs and revenues, to decision support systems and optimization of all processes related to the operation of real estate (Całka, Bielecka 2011). Although, there are a lot of various systems for property management, tailor-made systems for a particular user are still needed. A prototype of such a system for Police's Real Estate Administration is developed by the team from the Faculty Department of Civil Engineering and Geodesy at the Military University of Technology and ESRI Poland.

2. BASIC ASSUMPTION OF THE SYSTEM

Basic requirements for the Police Property Administration System, defined according to the methodology of designing information systems (Bedard 1999, Duecker 1990, Longley at al 2002, Oosterom, Lemmen 2001) relate to the functionality of the system, the scope of necessary data and the system architecture.

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System, whose users are the employees and officers of the Police, is aimed at significantly increasing the efficiency of management of real estate, including the rationalization of the financial expenditures incurred for the construction, expansion, renovation, and modernization of the individual objects. The system functionality includes analysis of ownership of the property, condition of facilities, financial expenses incurred for the renovation and modernization. Moreover, the system allows identifying which properties are redundant and should be spared (Bielecka, et al 2011). The collected data primarily concerned expenses and costs associated with maintaining the property of building, apartment and land, technical prarameters, location, as well as links with other systems (e.g. land and buildings registers, mortgages), and various documents related to the property (such as energy audits, technical audits, contracts with service providers etc).

The system architecture comprises of the central database, managed by PostgreSQL and ESRI SDE, and client web application. Access to the data is available by network services, while the communication with the database is done via permanent links based on TCP / IP (LAN, WAN, Internet).

Furthermore, it is assumed that system should be interoperable with other systems, which means that it can use the supplementary data (e.g. topographic data, orthophotomaps) provided by various public administration authorities in the frame of Polish infrastructure for spatial information.

The domain model for *Geographic Information System for the Police's Real Estate Administration* was elaborated using DBDesigner4, which is an open source program, enabling the design of the system in the form of UML diagrams, with functionality comparable to commercial systems such as IBM Rational Rose or Oracle Designer (DBDesigner4 2003).

The article discusses only the application schema of the Police Property Administration System, with particular emphasis on those elements which are spatial.

3. DOMAIN MODEL OF THE PUBLIC REAL ESTATE ADMINISTRATION SYSTEM

3.1. The modeling process

A domain model is a conceptual model of Universe of Discourse (a domain of interest) which describes the various objects (entities), their attributes, roles and relationships, as well as the constraints that govern the integrity of the model elements comprising the problem domain. It is intended for database and software developers as well as for system users, because it depicts relationships that exist in the modeled reality.

The formalised description of a domain model is called application schema. According to the ISO methodology (ISO 19 109:2005) the application schema serves two purposes:
   (1) achieves a common and correct understanding of the content and structure of data within a particular application field;
   (2) may provide a computer readable schema for applying automated mechanisms for data management.

These roles imply a four stepwise process for creating an application schema:

1) Surveying the requirements from the intended field of application.
2) Making a conceptual model of the application by identifying object types, their properties and constraints.
3) Describing the application schema in a formal modeling language according to defined rules.
4) Integrating the formal application schema with other standardized schemas, (spatial schema, quality schema, etc.) into a complete application schema.

3.2. Identification of the problem area

The problem area was identified during users' analysis and determination of the initial functionality of the system. Due to the complexity of the Police Property Administration System the domain model was split up into 24 packages that describe how the system is divided up into logical groupings by showing the dependencies among these groups (packages). 5 out of 24 package diagrams contain spatial objects, defined as point, line, or polygon. They are listed in table 1., and shown in Fig.1.

Table 1. List of packages that contain spatial objects

Package name	Object class	Spatial representation
AdministrativeDivision	Voivodship (wojewodztwo)	polygon
	County (powiat)	polygon
	Commune (gmina)	polygon
	Town	polygon
	Street	linestring
RealEstateAndLand	Parcel	polygon
	Building	polygon
RestorationZone	RestorationZone	polygon
PoliceBusinessObject	PoliceBusinessObject	point
PoliceInstitution	PoliceInstitution	point

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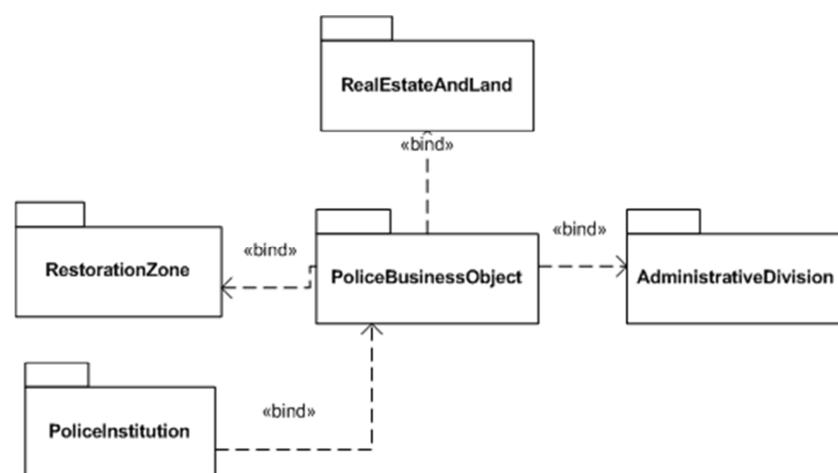Rome, Italy, 6-10 May 2012

Fig. 1. Part of package diagrams of the Police Property Administration System

3.3. Application schema

The application schema is a conceptual schema at the application model level and contains the complete and exact definition of the contents and structure of the dataset (ISO 19 101:2002). It contains selected parts of standardized schemas. The application schema may be purely internal for a certain implementation (either a system or a database), or may be common for two or more implementations. An application schema that conforms to the ISO 19100 series of standards shall be defined in a formal conceptual schema language (e.g. UML). This will allow automated processing of geographic datasets, e.g. encoding, data access, data transfer, querying and updating.

The application schema should contain and integrate parts of the other standardized schemas that are necessary to describe the structure and content of a particular dataset. The integration into the application schema of the standardized ISO 19100 series of standards schemas is defined in a rigorous manner in order to facilitate automated processing of geographic datasets. The rules on how to create an application schema for a geographic information dataset using the ISO 19100 series of standards schemas are found in ISO 19109:2005.

An application schema has the following parts:

- a feature catalogue - a complete and precise description of the semantic content of the geographic dataset following the concepts and structure defined in the General feature model (ISO 19 101:2002, ISO 19 110 2005);
- a specification of the reference system used to represent position or the reference system to which position is referenced (ISO 19 111:2007);
- the spatial object types used to represent the spatial aspects of features (ISO 19 107);
- the class diagrams (in UML) that describe the structure of a system by showing the system's classes, their attributes, operations (or methods), and the relationships among the classes (ISO/TS 19 103:2005.

Feature catalogue elaborated for the Police Real Estate Management System comprises more than eighty objects, which are:

- featureType (a spatial object type),
- Type (a conceptual, abstract type that is not a spatial object type),
- dataType (a structured data type without identity),
- Enumeration (a fixed list of valid identifiers of named literal values),
- codeList (a flexible enumeration that uses string values for expressing a list of potential values).

Each object is described by a set of attributes, associations and constrains. Attributes, associations and constrains are characterized by value type, definition (and alternatively description) and municipalities. Furthermore every object is atributted by the following atributes where the information when and who (which user) introduced (or last modified) the individual objects (instances) is stored:

- beginLifespan (Data_Utw),

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- modyicationDate (Data_Ost_Mod),
- userSetup (Uzytkownik_Utw),
- userModf (Uzytkownik_Ost_Mod).

The extract of feature catalogue, translated into English in shown in table 2.

Table 2. Part of feature catalogue for Police Real Estate Administration System

PoliceBusinessObject	
Attribute:	**name**
Type:	Character string
Definition:	Name of the Police business object
Description:	
Municipality:	0…*
Attribute:	**Id_inventory**
Type:	Character string
Definition:	Inventory number
Description:	
Municipality:	1
Attribute:	**Geometry**
Type:	GM_Object
Definition:	Geometry of the Police Business Object
Description:	As much as possible, the geometry should be a single point
Municipality:	1
Attribute:	**beginLifespan**
Type:	Data time
Definition:	Date and time at which this version of the spatial object was inserted or changed in the spatial data set.
Municipality:	1
Attribute:	**endLifespan**
Type:	Data time
Definition:	Date and time at which this version of the spatial object was superseded or retired in the spatial data set.
Municipality:	1

The main elements of the application schema are PoliceInstitution (Placowka) and PoliceBusinessObject (ObiektSluzbowy) (Figure 2), which are spatial objects as defined in the ISO 19 107 standard and INSPIRE Direcive (INSPIRE 2005). Their location is recorded using two-dimensional plane coordinates using the Transverse Mercator projection and the parameters of the GRS80 ellipsoid (EPSG Projection 2180 - ETRS89 / Poland CS920). Both the PoliceInstitution and PoliceBusinessObject are referenced to administration devision (voivodship, county, commune or town), the address as well the restoration zone (if appropriate).

The Police Real Estate is managed by the PoliceUnit, and can be a parcel, a building or a premise. It could be a separate object (PoliceBusinessObject) for which they are recorded all costs associated with maintaining the object, depreciation, the technical characteristics of the object including equipment, the number of employees and other.
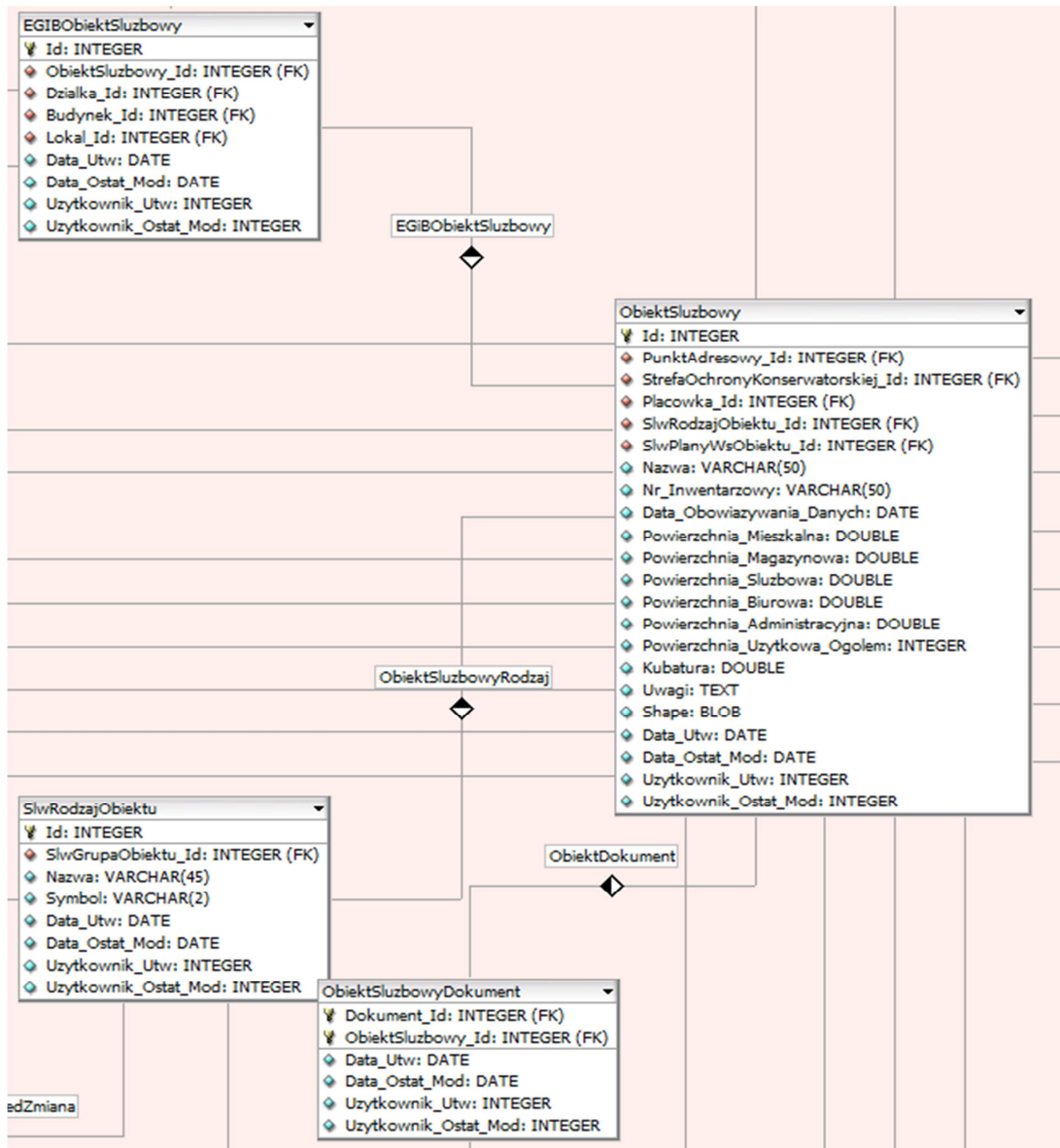
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Fig. 2. Part of application schema for Police Real Estate Administration System (in native language Polish)

The harmonisation of the *application schema for Police Real Estate Administration* with the standardized application schema from the ISO 19 100 standards are shown in figure 3.
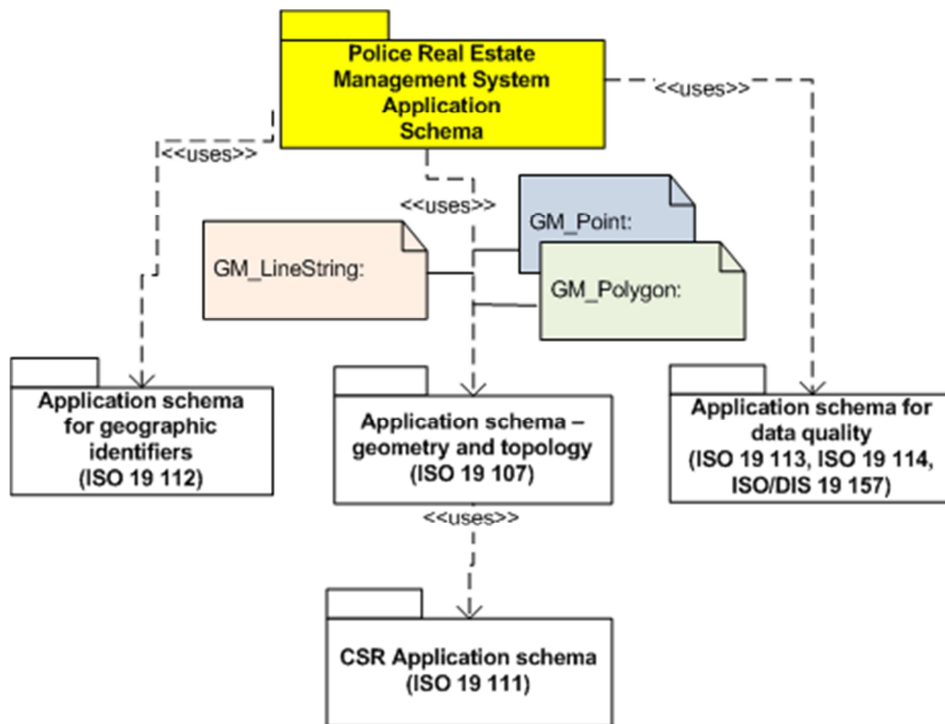
Fig 3. Application schema for Police Real Estate Administration

4. SUMMARY AND CONCLUSIONS

The domain model is created in order to represent the vocabulary and key concepts of the problem domain. The domain model also identifies the relationships among all the entities within the scope of the problem domain, and commonly identifies their attributes.

An important advantage of a domain model is that it describes and constrains the scope of the problem domain. The domain model can be effectively used to verify and validate the understanding of the problem domain among various stakeholders. It is especially helpful as a communication tool and a focusing point both amongst the different members of the business team as well as between the technical and business teams.

Including spatial objects in elaborating a domain model of the Police's properties management system, it allows geovisualization of the objects locations in the maps or ortophotomaps, as well as conducting a number of spatial analysis, like: spatial distribution of Police's Headquarters, spatial accessibility of Police stations, searching for the nearest Police station, searching for the shortest way etc.

The UML allows to describe the domain model in the form of application schema in the platform independent way.

The ISO methodology provides a set of standarised application schema which should be integrated into user's application schema in order to ensure interoperability.

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BIOGRAPHICAL NOTES

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