DESIGN AND IMPLEMENTATION OF THE SPATIAL DATABASE FOR THE ANALYSIS OF RESIDENTIAL ESTATE MARKET

Prof. Janusz Kwiecień, Ph.D.
Department Geomatics and Spatial Economy
UTP University of Science and Technology
Bydgoszcz, Poland
e-mail: jkw@utp.edu.pl– contact person

Małgorzata Krajewska, Ph.D.
Department Geomatics and Spatial Economy
UTP University of Science and Technology
Bydgoszcz, Poland
e-mail: m.krajewska@utp.edu.pl

Kinga Szopińska, Ph.D.
Department Geomatics and Spatial Economy
UTP University of Science and Technology
Bydgoszcz, Poland
e-mail: k.szopinska@utp.edu.pl

Abstract

In order to effectively manage the database on the real estate market, advanced IT technologies are necessary to provide mechanisms for entering, collecting, analysing and storing cadastral data. Solutions for the real estate market modelling should be treated as an important element for the development of the spatial economy. The main goal of this article is to present the spatial modelling technology of GIS databases for residential real estate using the UML.

Key words: spatial database, GIS, Unified Modelling Language (UML), real estate market, Poland

Introduction

The appraiser needs quick access to relevant information to effectively do his job. Each participant in the real estate market collects data on real estate that were subject to market transactions. Depending on the type of real estate surveyed, data may include transactions regarding the record plot, building or premises (residential premises and premises designed for other purposes). When assessing the value, the appraiser, in addition to analyse the descriptive data, should be able to locate the specific real estate in space in order to identify them spatially and obtain information about the real estate environment in order to select similar properties. The use of GIS technology (LONGLEY, 2005; PARZYCH, CICHOCIŃSKI, 2006; BYDŁOSZ, 2015; SZOPIŃSKA, 2017) seems to be an ideal solution for the appraiser, that provide mechanisms for entering, collecting, analysing and storing real estate data.
In Poland, property appraisers in their work use various tools to build the database on the real estate market, including, among others (BIELIŃSKI, 2015):

- Walor (http://www.pronet.com.pl) – version with the Partner program and without this program,
- Pricebook, (http://www.pricebook.pl),
- Maciej Solarz Internet Database (http://www.msrm.pl),
- The program of Research Centre of Real Estate Market Sp. z o.o. (http://www.ebaza.obrn.pl),
- The program of the Lower Silesian Real Estate Price Database,
- Krzempek-Pospieszałowski Transaction Analysis Systems (http://www.analizysat.pl).

A comparison of some possibilities of these individual programs tools is presented in the Table 1. It shows that the spatial presentation of the analysed data contained in these programs is based on the global system of Google Maps, which makes detailed spatial analysis difficult, for example: underground utilities, detailed topography.

This article presents a different proposal for the collection, description and spatial presentation of real estate data, which is based on the spatial modelling technology of GIS databases for residential real estate using the UML.

Table1. Basic information about programs.

BASIC DATA ABOUT THE PROGRAM			
PROGRAM NAME	Walor	Pricebook	internet database
PRODUCER	Pronet	Widelane	Maciej Solarz
WEB PAGE	www.pronet.com.pl	www.pricebook.pl	www.msm.pl
BASIC FUNCTION	database with a user-friendly interface for searching and presenting data	database with a user-friendly interface for searching and presenting data	database with a modest interface equipped with basic functions that enables searching and downloading data on own computer
PRINCIPLE OF OPERATION			
BUILDING A DATABASE	Database available only for authorized persons	Database available only for authorized persons	Database divided into a free part (non-standard properties) available to all appraisers and paid (other transactions) available to authorized persons
TYPES OF TRANSACTIONS IN THE DATABASE	Buildings, land, premises, rents, transmission easement	Premises, buildings, undeveloped, rents	Unusual properties, premises, buildings, undeveloped, rents
WAY OF DEFINING LOCATION	Database fields: province, county, commune, city, address	Database fields: province, county, commune, city, address	Database fields: province, county, commune and An additional field for manual entering address
INTEGRATION WITH GOOGLE MAPS	yes	yes	planned

Source: Own study.

The database model

At the moment, the most popular database design tool is Computer Aided Software Engineering (CASE). Using relevant CASE tools allows increasing effectiveness of database development. The logical model of the database which can be recorded using object modelling language – Unified Modelling Language (UML) can be used for automatic generation of the database schema that complies to the specification (DATABASE…). Spatial database can be designed in 3 steps: conceptual model, logical model and physical model. Building a conceptual model involves a range of thought processes and ideas regarding the project. The designer should imagine the problem and its solutions methodology. The main task in the conceptual process of building a data model is precise definition of objects of interest and identification of relationships between them.

At this stage, the way of writing descriptive attributes is determined and spatial properties of objects and relations between them. As a standard, UML is used, which is a record of expressing object models. UML is a graphic modelling language that enables graphic imaging and documenting of the real world in terms of objects. It is supported by the largest software and database vendors to assist with the documentation of the design tool (CASE), e.g. Sparx Enterprise Architect (DESIGNING…). The great advantage of UML is the ability to freely and repeatedly modify the diagrams described in it. UML has been accepted as a formal language for representing conceptual schemas in the ISO 19100 series (ISO 19101-1:2014). Based on the application schema, a physical model (implementation) of database is built.

The Conceptual Model

The outlines of the first version of the conceptual model that arises as a result of conceptual modelling are always born in the modelling person's head. It starts with the selection of a fragment of the world that will be modelled (Fig. 1). It is necessary to limit the world around us territorially and substantively. Territorial restriction means subtracting the decision about what area we will model: cities, commune, country, etc. (*universe of discourse* in Fig. 1). Substantial limitation means choosing the types of objects, ideas, facts, processes that should be in the model (universe of discourse). We decide to build a model for a spatial data system or some other. From all elements (objects and not only) located in a given area and related to a given subject, we choose the ones described in the model and then in the system.

In the next step, we begin to think about what information of objects properties we want to collect. Therefore, a conceptual model is created. If we construct a model that will describe more than one object, then there is the need to save our ideas, not to forget them, be able to show and discuss with

someone, then something to follow etc. In other words, we put our formalism on our model in the form of conceptual schema language, e.g. UML. Then we get a conceptual schema, which for a specific field is called the application schema.

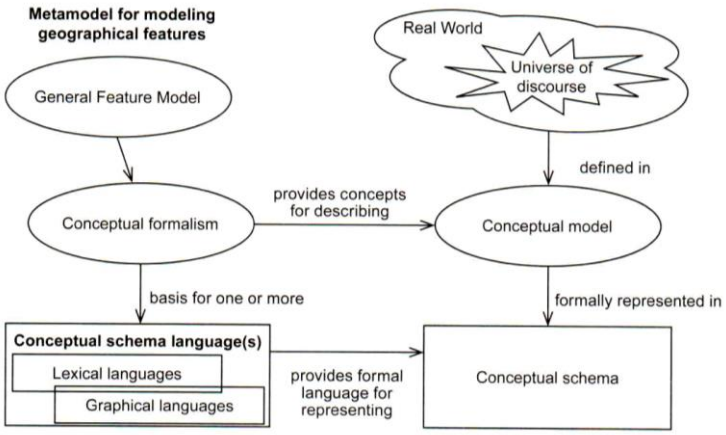

Fig. 1. From the real world to the conceptual schema.
Source: Own study on the basis of ISO 19101-1:2014.

The database schema

Designing ArcGIS geodatabase with Enterprise Architect 2017 was used for the spatial database of residential real estate. This environment provides the UML profile for modelling ArcGIS concepts and the ability to generate ArcGIS schemas as XML (DESIGNING...). Visualization of the diagram of relationships between classes of diagrams "Buildings", "Streets", "Districts",Traffic_str" for spatial database of residential real estate is shown in Figure 2.

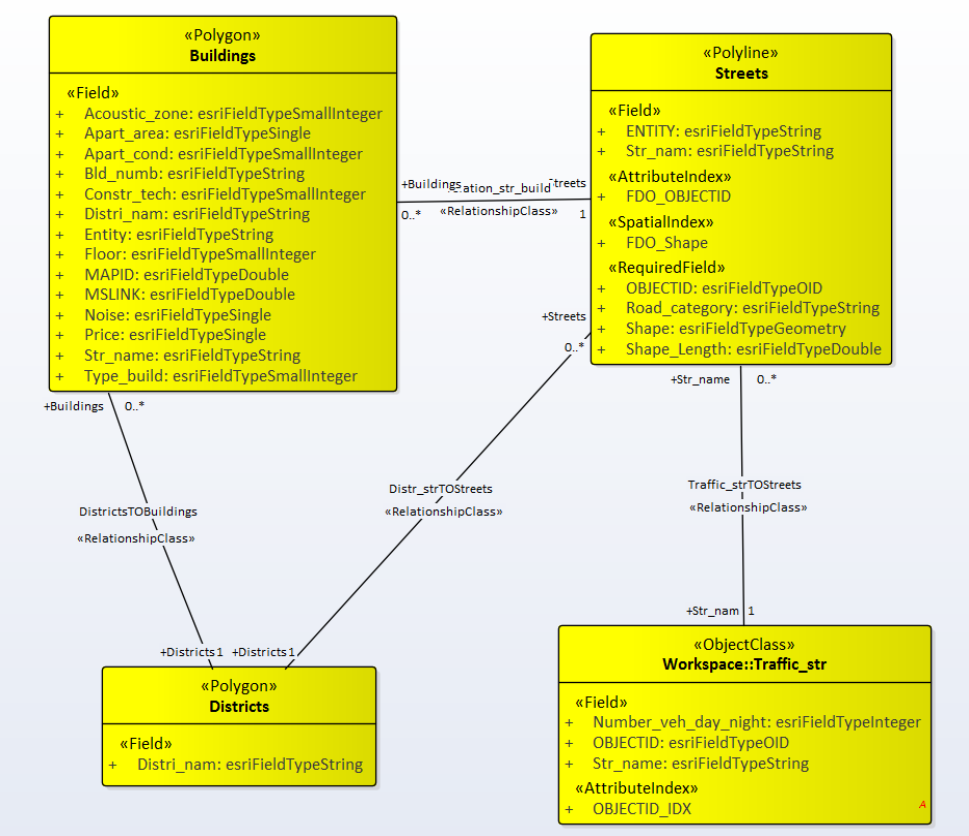

Fig. 2. Diagram of relationships between classes of diagrams "Buildings", "Streets", "Districts",Traffic_str" for spatial database of residential real estate.
Source: Own elaboration based on Enterprise Architect.

The source of spatial information for the property valuation system is cadastral parcels and buildings. Residential premises are characterized by a clear difference in relation to the aforementioned types of real estate. In the case of many apartments in one building, a flat in the database model is associated with the feature class: *Buildings*, thanks to which it can be located spatially. Traffic is defined as the table (*Traffic_str*), not as the feature class, in which objects have spatial attributes. Information about the size of noise acting on the building (flat) due to road traffic will be possible via a specific relationship between the table named *Traffic_str* and the feature class: *Buildings*. In the database model, there are also feature classes named: *Streets* and *Districts* with mutual relations. This allows for complex spatial analyses regarding the impact of noise on housing prices. At the end of the database design description, it is worth saying that this project defined the most basic attributes for the analysis of the impact of noise on housing prices. However, the proposed scope of the information described is not final, as it is possible to re-use the UML model schema for further objects and attributes modification.

The example of implementation of gis database for residential estate with road noise factor

After the design phase, it is advisable to repeatedly check the model semantic, to prevent any errors propagating to the implementation of the schema. Enterprise Architect provides a built-in model checker specifically for the ArcGIS Workspace models. After completing the model, Enterprise Architect can generate the appropriate ArcGIS schema as a XML Workspace document. The next step is to automatically generate an empty geodatabase in ArcGIS Catalogue folder and import to it a XML Document Workspace. The geodatabase preparation for use by property appraisers includes the import of spatial data for districts, buildings and streets to the system. ArcGIS allows us to import data from many formats, such as: * .shp, * .dgn, * .dwg and * .dxf.

A database for real estates in GIS is an ideal source of spatial information for property value appraiser who needs a piece of information for appraisal. Every software belonging to the group described as desktop GIS has tools for finding, sorting and analysing the descriptive and geographic information in the geodatabase (ArcGIS Desktop Help). How we can use ArcGIS system for spatial analysis is described below. ArcGIS allows you to search for data, and then select records in the database according to built SQL expressions. We can use comparison operators, such as: equal (=), not equal (<>), greater than (>), smaller than (<), greater than or equal (> =), less than or equal (<=), logical operators, such as AND, OR, NOT and arithmetic operators, e.g. SELECT * from the *Buildings* WHERE *Str_name* = 'Aleje Kardynala Wyszynskiego' AND *Noise* > 65 AND *Noise* <70 (Fig. 3).

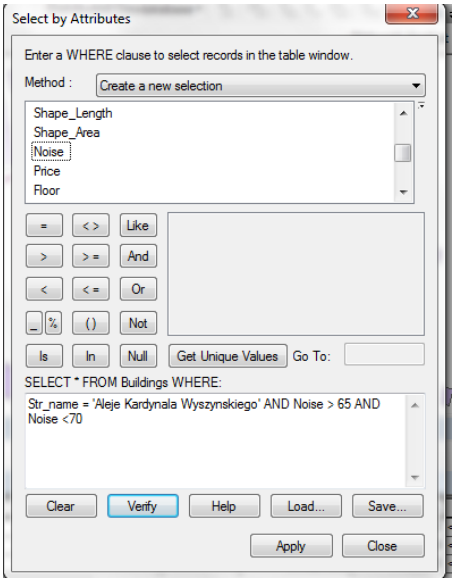

Fig. 3. Selection by attributes dialog box.
Source: Own elaboration.

The study area, with an area of 1.24 km^2, was located in the northern part of the city of Bydgoszcz (Poland), near national road DK5 – Aleja Kardynała Stefana Wyszyńskiego (hereinafter referred to as Wyszyńskiego St.), the exit road from the city towards Gdańsk. It is part of the Bartodzieje housing estate.

This area is dominated by multi-family residential use, with buildings from the 80s of the 20th century (Fig. 4a and 4b).

Fig. 4. a) Study site in the context of the Bydgoszcz city b) Wyszyńskiego St.
Source: Own elaboration.

This query allows for spatial analysis regarding the location of buildings at Wyszyńskiego St., where car traffic generates noise in the range from 65 to 70 decibels and other descriptive attributes of the localized building, such as: flat price, floor etc. (Fig. 5).

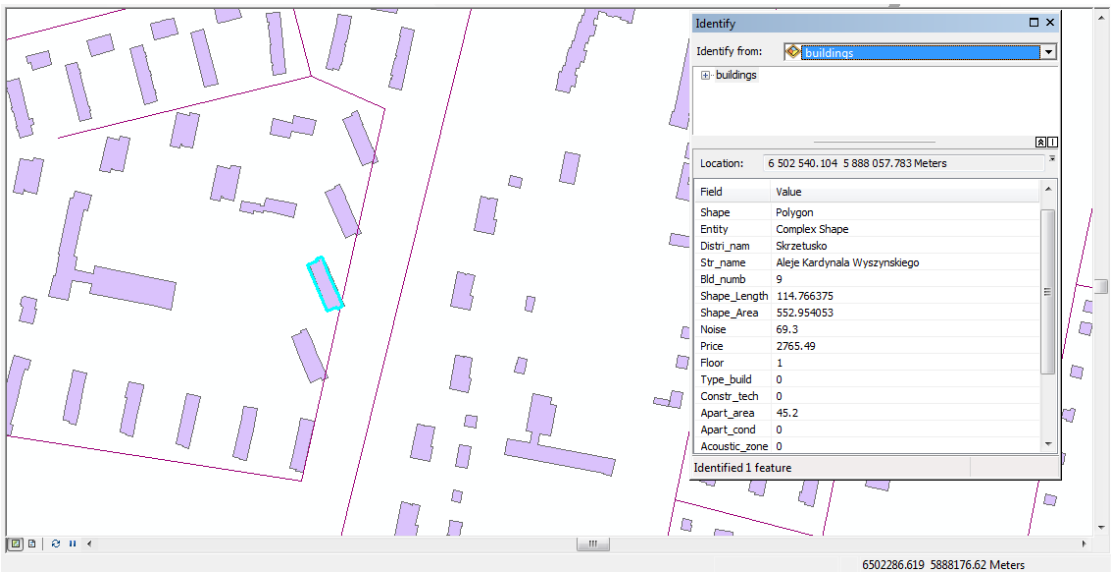

Fig. 5. Location and identification of the selected property's attributes.
Source: Own elaboration.

Summary and conclusion

Spatial identification of real estate in connection with full information about their features and environment, including technical infrastructure, stored in one database is desirable for the valuation process and all activities related to the real estate management. Therefore, it is advisable to search for solutions based on various IT tools. The database model presented in the article is an example of database design using the Enterprise Architect program that applies UML. This program also includes a module for database design in the ArcGIS environment. The authors realize that the proposed database model in ArcGIS can be a problem for people who have never had contact with the ArcGIS software and also UML. Therefore, the intention of the authors in the future is to work on creating a more user-friendly application that could facilitate the use of database in spatial analysis of residential estate transactions.

References

ARCGIS DESKTOP HELP, http://webhelp.esri.com (accessed on 14 March 2018).

BIELIŃSKI, T. 2015. *Narzędzia wykorzystywane przez rzeczoznawców majątkowych do budowy bazy danych o rynku nieruchomości – uzupełnienie.* Biuletyn Nieruchomości, 2: 7-23.

BYDŁOSZ, J. 2015. *The Application of the Land Administration Domain Model in Building a Country Profile for the Polish Cadastre*. Land Use Policy 49: 598-605.

DESIGNING ArcGIS Geodatabases with Enterprise Architect, http://sparxsystems.com (accessed on 27 March 2018).

DATABASE Modelling in UML Originally published in Methods & Tools e-newsletter, http://www.martinig.ch/mt/index.html (accessed on 16 March 2018).

ISO 19101-1:2014(en), Geographic information - Reference model - Part 1: Fundamentals.

LONGLEY, P.A., GOODCHILD, M.F., MAGUIRE, D.J., RHIND, D.W. 2005. *Geographic information systems and science, second edition.* John Wiley and Sons Ltd, New York.

PARZYCH, P., CICHOCIŃSKI, P. 2006. *Application of Geographic Information Systems for Real Estate Valuation Support*. Shaping the Change XXIII FIG Congress Munich, October 8-13, Germany.

SZOPIŃSKA, K. 2017. *Creation of Theoretical road traffic noise model with the help of GIS*. Proceedings of the "Environmental Engineering" 10th International Conference Vilnius Gediminas Technical University, Vilnius, Lithuania, p. 1-8.