Application of Geographic Information Systems for Real Estate Valuation Support*

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Key words: Geographic Information System, valuation, real estate parameters, data processing tools.

SUMMARY

The land and mortgage registers, the cadastre of real estate, the records of the utility networks and spatial development plans – the most important databases of National Geographic Information System (GIS) in Poland – are basic information sources used for valuation of real estates. But unfortunately, these databases are distracted, they are managed by many different institutions and the access to them is often troublesome. It would be useful to collect all the necessary data in the form of one suitable database, containing information describing every real estate. The use of relational database technology for spatial data storage makes possible the application of modern object oriented methods for such database design.

The analysis of the National GIS databases detailed subject range proved, that they do not contain the complete set of the required information to make the valuation. Particularly the spatial attributes of real estate and relationships with other objects in the direct and further neighbourhood (utility networks, major roads, industrial plants) are essential. Most often such data are not recorded directly in the databases.

The authors suggest the use of GIS data processing tools for calculation of additional real estate parameters, essential for valuation process. In particular, the buffering function, belonging to the canon of spatial analyses, which can determine the real estate distance to other objects, and functions from the domain of geographical networks analyses, making possible calculation of shortest paths, deserve the attention. The comparison of required and available data and the knowledge of GIS functionality allowed to present a proposed range of data, which can be directly transferred or generated with the help of GIS software.

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1. INTRODUCTION

One of the basic methods of real estates market value determination is the valuation accomplished by the means of comparative approach. This approach assumes, that the market value of real estate is assessed through the comparison to other similar real estates, for which transaction prices and characteristics differing these real estates and having the essential influence on their value are known. One of the essential difficulties of comparative approach is the necessity of possessing information about real estates similar to appraised, which were subjects of trade on given property market.

Assuming the need of valuation process automation, for example for the purpose of mass appraisal, the necessity of above mentioned data collection in the form of suitable database ought to be foreseen. It should contain information characterizing real estates, also in spatial domain, to allow their adequate description and differentiation.

However construction of independent database of real estates from the ground up is a long–lasting and expensive task. Fortunately this problem can be solved with the help from Geographic Information Systems (GIS). Within the framework of works on national geodetic and cartographic resources conversion into digital form carried on in Poland for fifteen years, there are more and more databases produced, encompassing the land and buildings cadastre, the spatial registration of utility infrastructure, topographical objects with the digital terrain model, as well as various environmental problems. For some time past the land and mortgage registers are the subject to modernization, through the migration to the electronic form. It can be supposed, that the databases of Geographic Information Systems would be able, at least partially, to serve as data sources for real estate attributes.

2. THE IDEA OF GIS FOR PROPERTY MARKET

It is however necessary to notice, that presented above databases are distracted, managed by many different institutions and acquiring the data from them can be troublesome. The creation of separate fiscal cadastre will cause the necessity to divide the resources to manage the two records. Additionally the collection of the same data will significantly enlarge necessary financial expenditures. The ideal solution would be the creation of efficient Geographic Information System, connected to land and mortgage registers and making possible concurrent handling of both property market and national geodetic and cartographic resources.

The basis of such Geographic Information System should be spatial database containing data stored thus far in above mentioned datasets. The relatively new technology that can be used

for this purpose is so called geodatabase (Zeiler, 1999). Unlike earlier commonly used georelational data model, all attributes of objects (including position and shape) are recorded in a table of relational or object–relational database. A main purpose of the geodatabase is the manipulation of complex geographical data with uniform data model independent of the relational database it is based on.

Relational databases dominate on the market because they implement simple, elegant and well–understood theory. This simplicity is simultaneously a strength and a weakness – it is conceptually straightforward to build relational databases, but difficult to model complex data.

Geographical databases contain complex data. The shapes of line and area objects are structured sets of coordinates that do not record themselves properly in fields of standard types, such as: integer, real or string. Besides, objects are combined into systems that have explicit topological relationships, implicit spatial relationships and other relationships of the general kind. However the constructors of databases managed to walk round this limitation allowing the use of relational database design methods also to geographical information.

The traditional design of relational database consists of two basic steps – the expression of a logical data model and the physical implementation of database models (or schemas). The logical data model corresponds to user's view of data, while the model of the database implements the data model within the framework of the relational database technology.

An essential advantage of the geodatabase is that although it is a physical implementation of data, it allows to structure the data the way that is close to the logical data model. The similarity however does not mean the lack of differences: classes of objects can be split or joined during implementation in tables, and rules and relationships can be expressed in several ways.

The logical data model is an abstraction of the objects occurring in a particular application. This abstraction is converted into database elements. An object represents an entity such as a building, a parcel or an owner and is recorded as a row. An object possesses a set of attributes, that characterize its properties, such as name, a measure, a classification or an identifier (a key) to another object. Attributes are recorded in a database in columns (called also fields). A set of similar objects forms a class, stored in a database as a table. Every object in a class has the same set of attributes.

The key task in building a logical data model is precise definition of objects of interest and identification of relationships between them. Some examples of objects are streets, parcels, owners and buildings. Some examples of their relationships are "located at", "owned by", and "is part of".

In the past logical data models were often drawn in form of so called entity–relationship diagrams. Lately however, the greatest popularity achieved Unified Modeling Language (UML), which is a standard notation for expressing object models, promoted by leading

software and database manufacturers. It was also accepted as the formal language for description of models and conceptual schemas in the series of ISO 19100 standards devoted to geographical information (ISO 19101:2002). Of course UML can also be used for "drawing" object–oriented models of geodatabase. The graphic notation particularly makes easy tracing of relationships between individual objects.

A physical database model is built from the logical data model. Previously, most often a specialist in relational databases received the logical data model and used database administration tools to define the database schema and create new database ready for data transfer and entry. But now we have at command one more possibility: the CASE (Computer Aided Software Engineering) tools. The logical model of database recorded using UML, can be used to automatically generate the schema of database conforming to the particular specification (Perencsik *et al*, 2004).

3. DATA AVAILABILITY

It is assumed that the majority of data required for valuation will come from the mentioned above sources. At first sight it seems, that such situation really most often will take place: information on location, the shape, the soil–based land classification, the function and characteristics of building should be recorded in the land and buildings cadastre; destination of the ground is described in the local spatial development plan; the accessibility of utilities is described by the spatial registration of utility infrastructure.

But unfortunately the access to certain data not necessarily gives the possibility of their immediate use, which means that in the most cases that data itself does not constitute attributes of real estates. Some attribute values result not from properties of objects, but from relationships between them. Another ones are the derivatives of certain characteristics (for example geometrical) of real estates.

Of course one always can determine attributes of real estates using map or performing reconnaissance. The look on map with experienced eye allows to obtain the knowledge where given objects are located, what kind of objects they are, how they can be reached with roads or other transport means, what objects can be found in neighbourhood or nearby. The additional information can be obtained during interactive session with digital map recorded in the computer and presented on the monitor. This interaction shows information which is not visible on the printed map. For example one can show all known attributes of objects, form the list of all objects being found along the way from one point to another or conduct a simulation of travel time.

Presented above and commonly used method of object attributes determination on the basis of maps, requires participation of the man (the operator). In case of mass appraisal it would cause enormous expenditure of labour, resulting in huge costs. Therefore the database designed in above described manner should be additionally equipped with toolset allowing the calculation of necessary additional real estates attributes. The authors suggest determination of these indirect real estates attributes with the use of analytic functions of GIS

software. Below are described proposals of determination methods of several attributes, which are the most often taken into consideration during valuation process.

3.1 Location (zone), Destination in Spatial Development Plan, Fashion (popularity), Soil–based Land Classification

The collection of these attributes in one clause is not accidental. They inform about real estate belonging to areas of some superior partition of geographical space (fig. 1). This partition can get out of certain strictly specified conditions such as destination in spatial development plan or land classification. It can also be the result of certain informal, but commonly used classification – an example can be assignment to the zone of town: central, downtown, intermediate or suburban. And at last it can be the effect of the absolutely subjective attractivity estimation of some area, in other words fashion. Unfortunately this last parameter can not be calculated with mathematical methods, but the person familiar with the property market (for instance the employee of estate agency) can delineate it precisely enough. Apart from the source of data about the partition of ground related to values of real estates, the assignment of given real estates to particular zone can be done through the execution of "intersect" function, assuming that borders of zones coincide with lots lines. Additional detailed considerations are required in case when the given property is not entirely contained in the element of given partition. The selection of zone in which resides greater part of real estate appears to be the most straight solution.

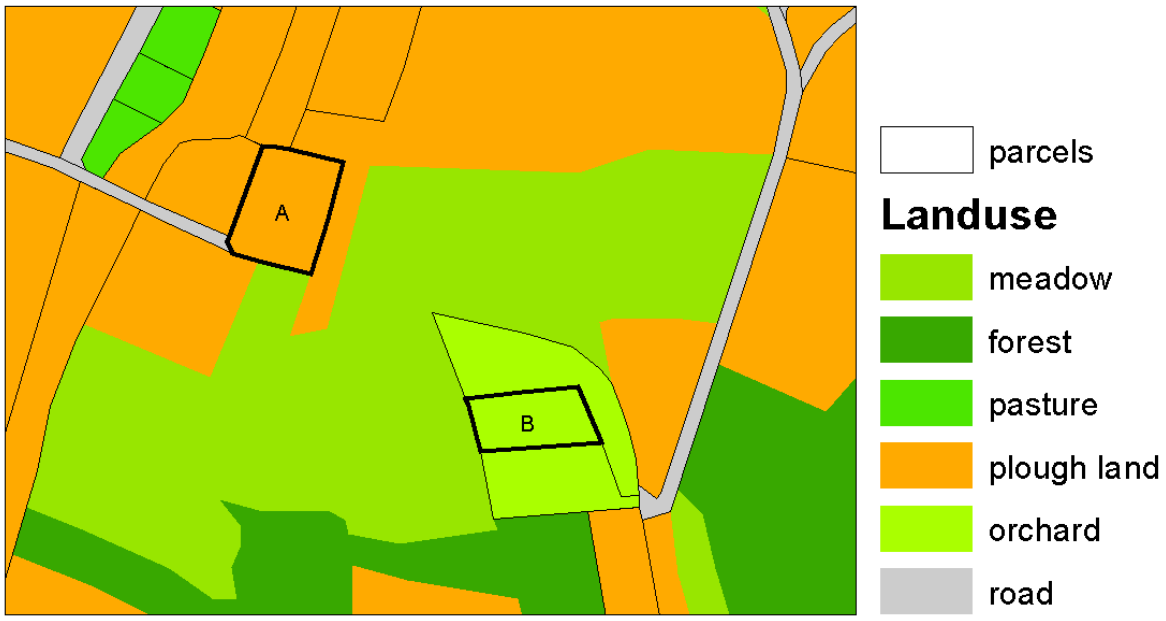

Figure 1. Parcel A belongs to the zone "plough land", while parcel B belongs to the zone "orchard".

3.2 Geometrical conditions

Geometrical conditions of real estates must be considered in two aspects. Firstly – the shape: it is known that elongated parcels are less profitable in terms of development than the ones almost square (fig. 2). There is however the lack of detailed guidelines how the given shape translates into the value of real estates. The second aspect is the form of surface (fig. 3). Generally it can be stated, that too large slope of ground is disadvantageous (fig. 4). But also certain forms, for example rocks, can have positive influence on price.

The basic spatial data source of the global character in Poland is the Topographical Database. It contains data corresponding to topographical maps in scale 1:10000. Positional data accuracy and level of detail resulting from such scale is too low, preventing this database from utilization in valuation of real estates. Only the part of this database containing digital terrain model can become useful, but only when the warranted accuracy of this model amounting 1 metre is sufficient. However it seems, that another dataset of such territorial range and better accuracy containing heights should not be expected in the nearest future. This database is still on the stage of initial works and it is not known, when it becomes operative.

On the basis of height data the shape of terrain, the slope and the aspect – the direction of steepest downhill slope can be determined.

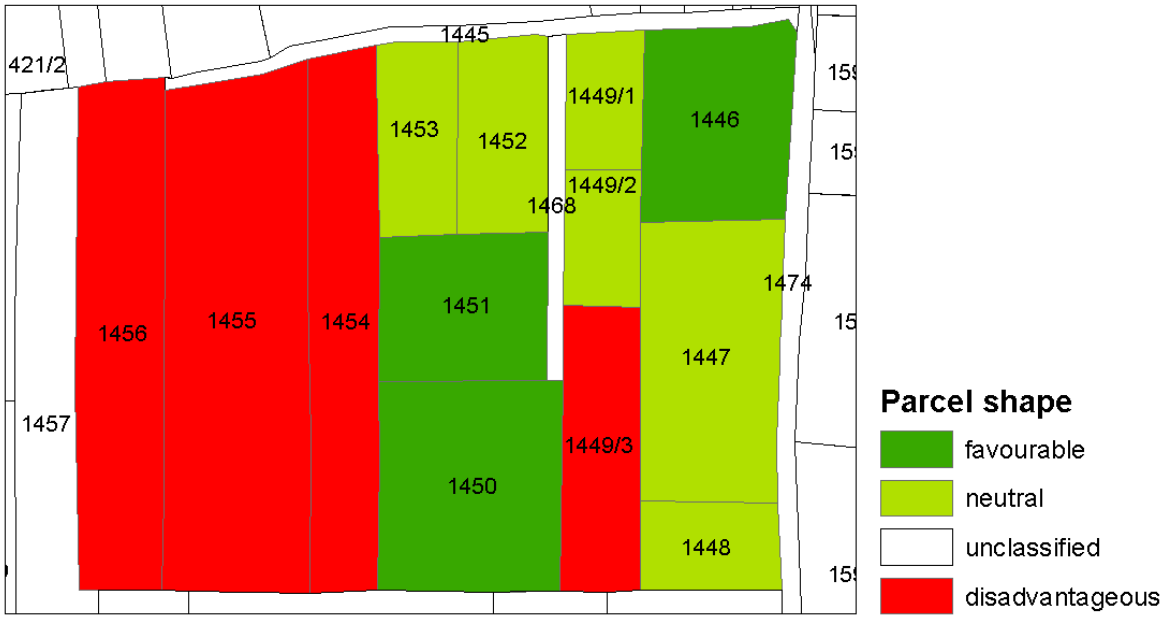

Figure 2. Parcels classified by their shape: almost sqare are ”better”, elongated are ”worse”.

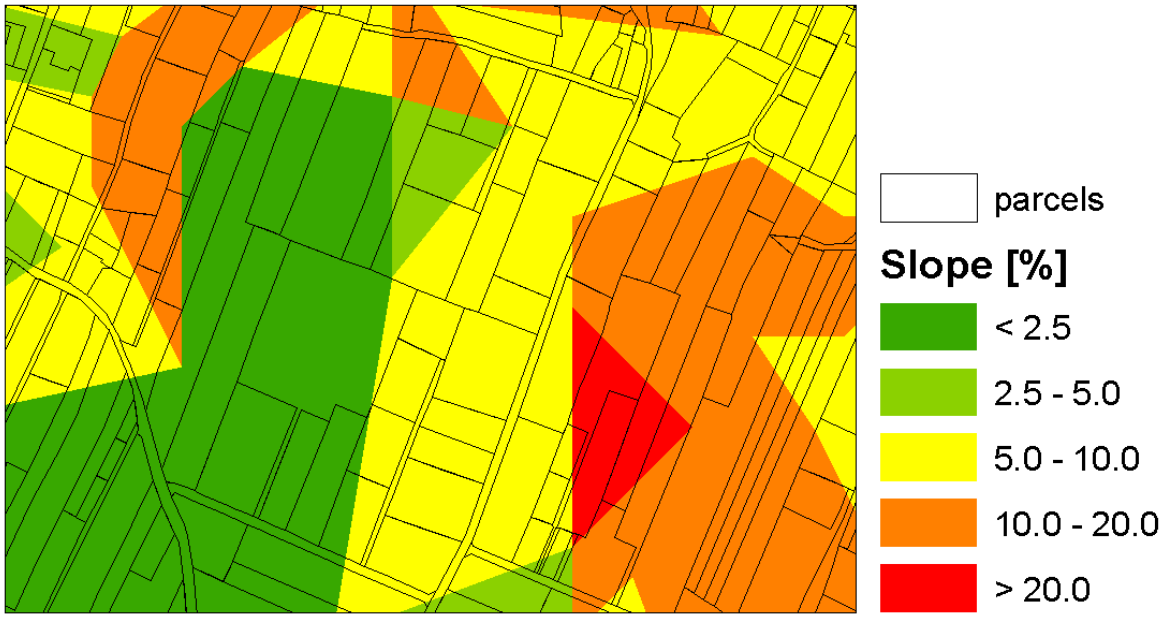

Figure 3. TIN triangles classified by their slope.

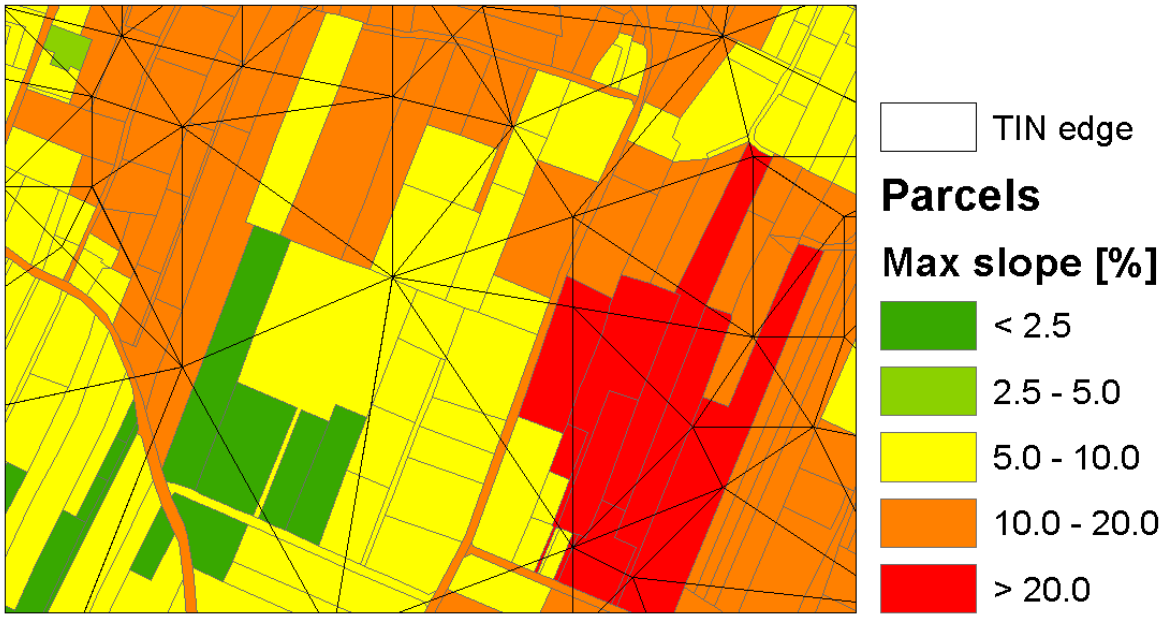

Figure 4. Maximum slope assigned to parcels.

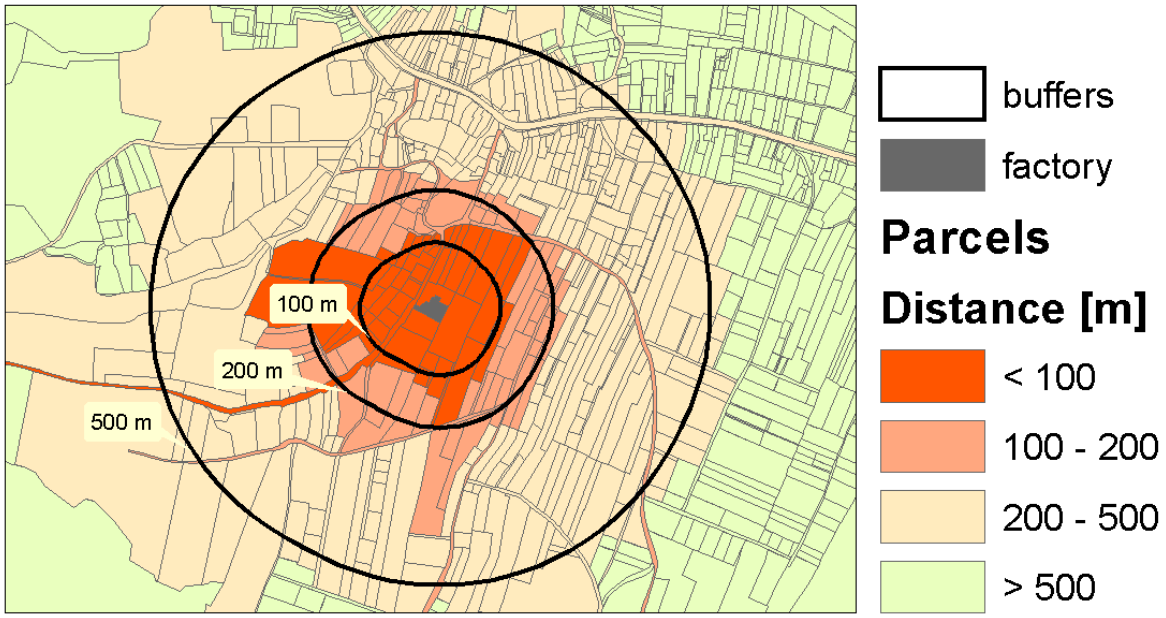

Figure 5. Buffer zones around small, but very noisy factory.

3.3 Surroundings (neighbourhood)

It is necessary to determine what kind of objects and in what radius should be looked for, both increasing and decreasing real estate value (fig. 5). The information about parcel vicinity, existing or planned, can be obtained from the local spatial development plan. If the parcel is located inside any zone, it is evident that neighbouring parcels have the same destination. In the opposite case topological geometrical data models, available in advanced GIS software, allow the qualification of neighbourhood and mutual crossing of geographical objects (fig. 6).

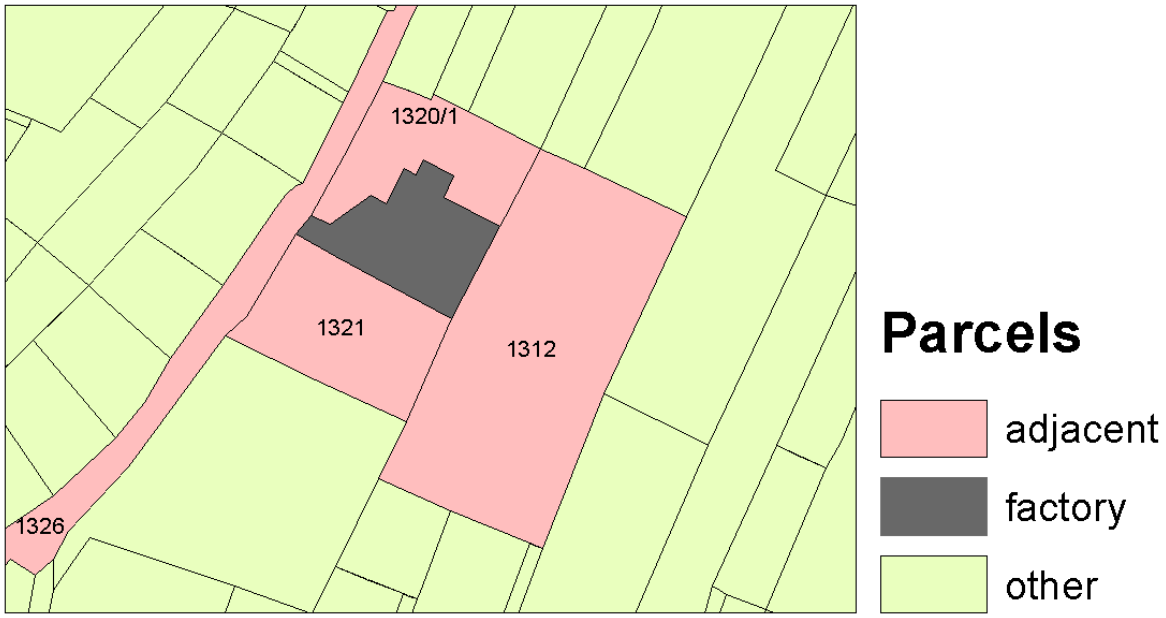

Figure 6. Parcels adjacent to factory.

Figure 7. Buffer zones around utility.

3.4 Utility Networks

Bare information on the location of given network does not provide the information about the possibility of connecting. Only the determination of its position in relation to parcel or building, will allow to answer the question, whether connection is possible (economically justifiable). Keeping in mind the level of charges drawn for connection by providers, every

additional metre of given medium distance from the real estate is also essential (fig. 7). Furthermore it is necessary to determine whether, except nearness, network parameters make connection possible. Managers of given network, or administrators of appropriate database should foresee the attribute of every network section, recording the information about possibility of its extension and new customers connection.

3.5 Communication Accessibility

The journey to real estate can be considered in three categories: distance from the town centre, quality of access road reaching the parcel and accessibility of mass transport facilities. For the proper calculation of this journey, it is necessary to designate the centre around which the life of inhabitants concentrates. The road distance from given parcels to such a centre can then be calculated (fig. 8). It is however necessary to notice, that small towns situated nearby large cities, despite possessing their own centres, gravitate toward these cities.

Figure 8. "Best route" from the parcel to the centre and road surface types.

According to regulations on management of real estates every lot must have provided driveway. The quality of this driveway depends on the type of road surface. The use of network analysis functions allow the calculation of route to nearest higher category road on a given area (of course basing on road network data) and then the determination of worst surface type. Regarding the accessibility of mass transport facilities, several nearly situated stops can be selected, and then the nearest can be found, considering the movement along roads or paths (fig. 9).

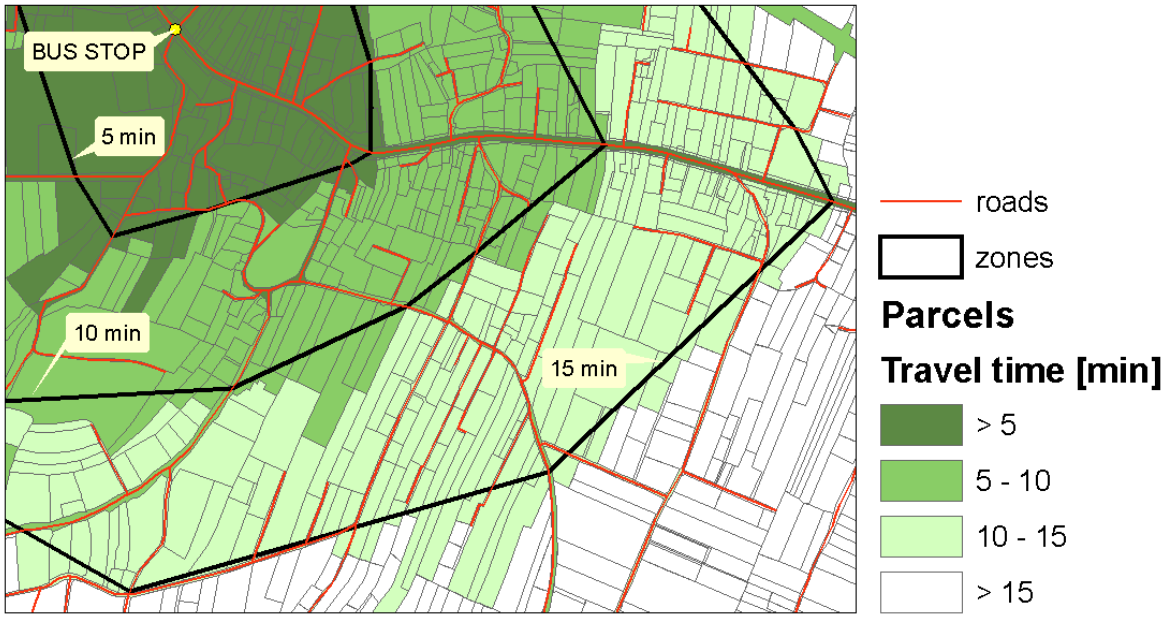

Figure 9. Zones of given travel time from bus stop.

These analyses require however the access to additional data – the road network, additionally enriched with the information about the course of the mass transport (buses, trams, trains) lines. Probably the information from the topographical database would be useful. In case of lack of such data, it is always possible to determine approximate road centerlines on the basis of information about land usage recorded in the cadastre of real estates (Cichociński, 1996). Unfortunately this method allows to obtain only geometrical data, without such essential attributes as road category or width. Only on the basis of succeeding transformations (namely the intersection of road centerlines with cadastral data), it is possible to obtain information about surface type, of course if it is recorded in cadastral database.

4. CONCLUSION

Presented above proposals of determination methods of values of particular attributes essential to the valuation of real estates do not dissolve the whole problem. This way only allows to determine the attributes of individual real estates. However keeping in mind "the generality" of valuation, the automation of this process needs to be considered. It requires the formulation of procedures algorithms and then their implementation in the environment of GIS software, also used for building the real estates database.

Summing up, the conclusion can be drawn out that accomplishment of real estates valuation on the wider scale will be much easier and less expensive with the use of Geographic Information Systems, interpreted as the data source, the tool for collecting them, as well as the set of functions to process them.

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