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GEOINFORMATION TECHNOLOGY OF THE MASTER PLAN GEOSPECIAL PROFILE DATA SETS DEVELOPMENT

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Purpose. The purpose of the research is development of an object-oriented geoformation model of settlements master plans geospatial profile data sets. The topicality of the research is due to the need to meet the current requirements of the legislation on the development of geospatial profile data sets as, considering the importance part of master plan documentation of increasing the level of automation and level of master plan digital data quality for their further effective use in the urban cadastre system. **Methodology**. The basis of the master plan geoinformation model development methodology is a traditional approach to database (DB) design, which includes levels of conceptual, logical, and physical modeling. For conceptual modeling UML (Unified Modeling Language) is used, which is recommended as the main modeling tool in the geographic information/geomatics complex of international standards. A software tool that supports the interactive mode of creating UML diagrams Visio is used. For implementation of the master plan geospatial data base and the behavioral component of the geoinformation model, the expansion of the standard language SQL99 with the new geometry data type and built-in functions that provide storage, processing, and analysis of geospatial data in relational database management systems are used. The proposed models in the research is realized in the object-relational DBMS PostgreSQl/postgis and geographic information system QGIS. **Results**. The typization of the geospatial profile data sets' organization models is done in GIS. The advantages of object-relational data model for the preparation of geospatial profile data sets in the framework of the master plan were substantiated. A technological model for the formation of geospatial profile data sets based on the geospatial data base of the master plan objects data base was proposed and implemented. An example of the implementation of methods for the master plan restrictions zones automated construction using SQL-function is given. **Scientific novelty**. The master plans geospatial profile data sets formation model was developed, based on the integration of object-relational databases and geographic information systems and master plan's geospatial profile data sets object-oriented model was developed. Implementation of which in the object-relational DBMS ensures data independence from means and formats of instrumental geographic information systems. **Practical significance**. The proposed master plans' geospatial profile data sets object-oriented model provides for an efficient increase of creation and use of master plans geospatial profile data sets in the urban cadastre.

Key words: urban planning documentation; geospatial profile data sets; master plan; object-oriented model; geospatial data.

Introduction

Modern requirements for urban planning documentation and urban cadastre systems include, in particular, the formation of geospatial profile data sets in a single classification and a coding system of urban objects, which together with metadata sets are registered in databases of the urban cadastre information system.

Until now there is no integral system of normative documents that regulate the types of geospatial profile data sets, the geospatial objects classes catalog, conceptual and logical models of geospatial profile data sets, and there are no formulated requirements for digital formats and coding of urban planning documentation components for their unambiguous identification, registration, storage, search, and for their use in the urban cadastre system. Until now the graphical approach to the documents preparation is oriented on preparation of cartographic images and not their GIS models [Lyashchenko A., 2013], [Horkovchuk, D., 2016].

The absence of the listed normative documents system components for the master plan geospatial profile data sets does not allow to switch from automation of the cartographic documents preparation to the geoinformation model of design solutions for GIS of the territories management and information resources integration into the national infrastructure of geospatial data.

Aim

The aim of the research is to develop an object-oriented geographic information model of settlements master plan geospatial profile data sets.

The topicality of the research is due to the need to meet the current requirements of the legislation on the development geospatial profile data sets as part of master plan documentation graphical part and importance of increasing the level of automation and level of master plan digital data quality for their further effective use in the urban cadastre system.

Methodology

Geospatial profile data sets (GPDS) can be defined as a unified set of geographic information objects models, which are contained in the spatial schemes and plans of urban planning and project documentation in the state geodetic coordinate system USK-2000 and the single system of construction objects classification and coding for the urban cadastre databases development.

In the modern geographic information systems, three main models of geospatial profile data sets in GIS are used: file geoinformation model (FGM), georelational (GRM). and object-relational (ORM) [Maksymova Yu., 2017].

Despite the fact that these models evolved from a file to object-relational model, they are still used in GIS.

In reference to file and georelational models, their structure, content, and intellectualization tools in the form of procedural knowledge of applied modeling remain platform-dependent, and therefore have limited possibilities for both the exchange and transfer of knowledge from the designer to the computer. Conceptually, only ORM, which in a single environment, combines both basic geospatial data in independent formats and independent from instrumental GIS basic and applied behavioral modeling functions, and ensures the implementation of geospatial models and spatial analysis software independently of the GIS platform.

Thus, the key hypothesis of the research is based on the fact that the use of the object-oriented model of GPDS based on the ORDBMS allows maximizing the unification level of attributive and spatial data and the unification level of the data geoinformation analysis means (Fig. 1) [A G-O Yeh, 2005], [Formulation of gis based master plans for amrut cities. Design and Standards Ministry of Urban Development, 2016], [Integrating geographic information systems and agent-based modeling techniques for simulating social and ecological processes, 2002], [Bretagnolle, A., Daude, E., Pumain. D.: From Theory To Modeling: Urban Systems As Complex Systems. CyberGe: European Journal of Geography, 2005, 355, 1–17].

The core of the technological model of the master plan (MP) GPDS formation, which is presented in Fig. 2, are: the database of the master plan objects; a block of GPDS objects spatial analysis and modeling application means there is interaction with both the database of the MP objects and instrumental means of GIS.

The database of the master plan objects is the basis of modeling and the source for the formation of digital schemes in accordance with the established rules of mapping and the electronic schemes images formation in GIS. Means of instrumental GIS provide connection with the database of the master plan objects and according to the results of geoinformation modeling in the automated system of master plans GPDS preparation (Fig 2), the following components of the documentation set in the exchange data formats prepared for the transfer for registration in the urban cadastre system: MP geospatial profile data sets; sets of electronic raster plans (schemes) in accordance with the requirements of DBN B.1.1-15: 2012 [DBN B.1.1-15:2012. Composition and content of the settlement master plan from 2012.07.13]; text materials (the form of technical and economic indicators is generated by the system automatically); metadata about the set of documentation and its components, including the GPDS; application schemes (with a description of the data structure and the classification system that is used).

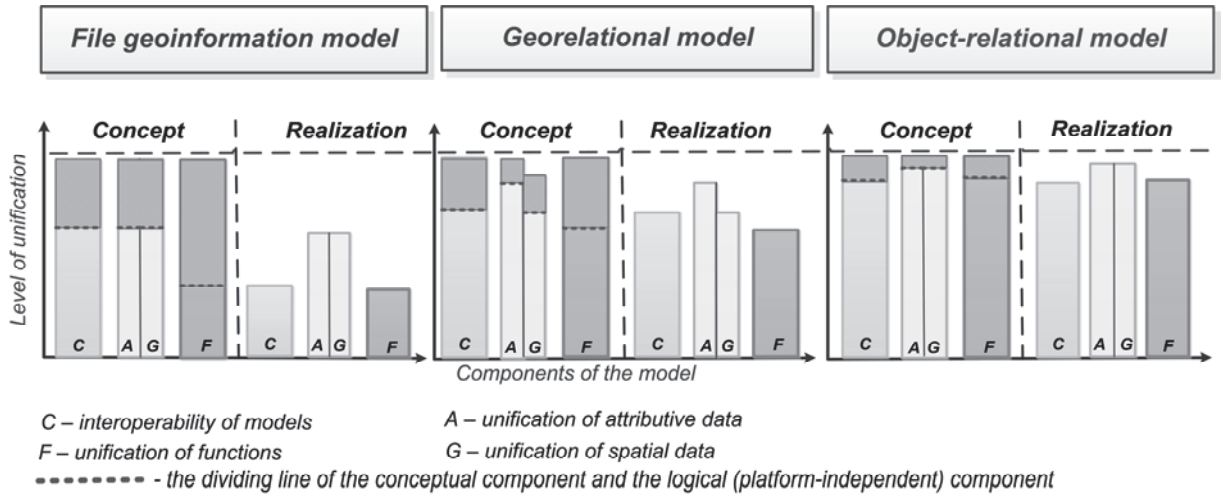

Fig. 1. Levels of structure and content unification in the geospatial profile data sets models

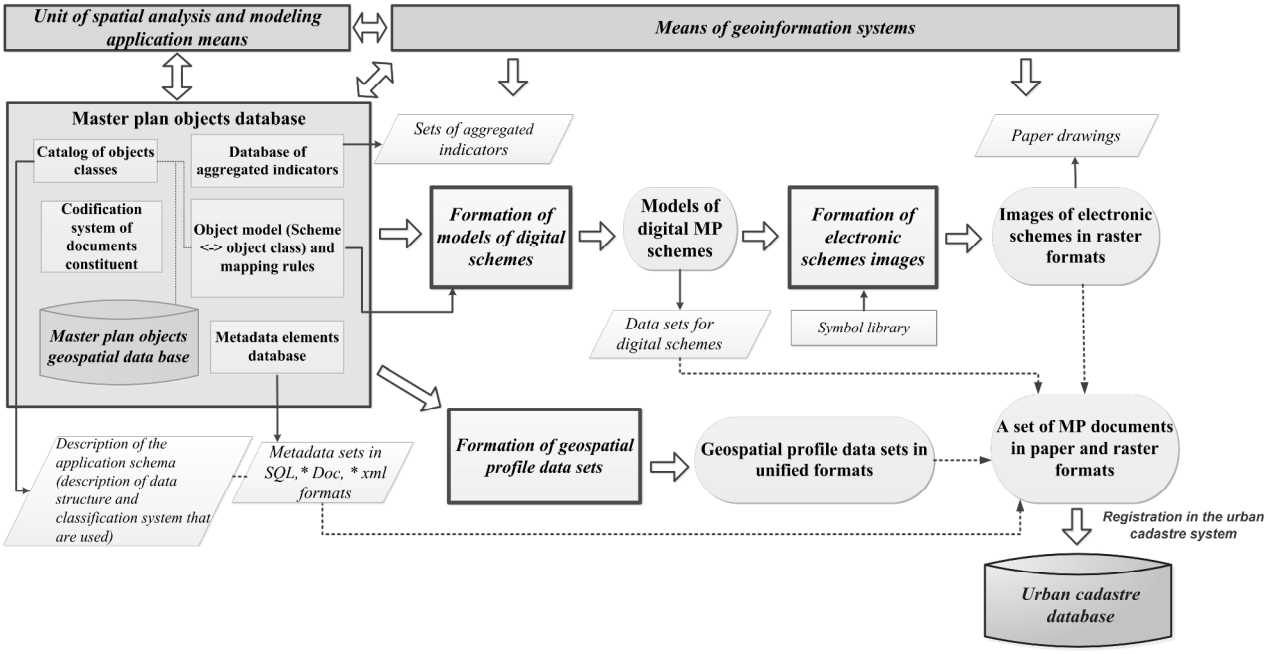

Fig. 2. Technological model of master plan GPDS formation based on the geospatial data base

In the structure of the master plan geospatial data object-oriented model, presented in Fig. 3, the following components are highlighted:

1) a knowledge base that stores information about the information resources of the GIS of automated system of master plans GPDS preparation and includes: a classification of urban planning documentation sets that provide unambiguous identification of electronic copies of the master plan documentation and GPDS objects; the application scheme of the geospatial data base, and the catalog of master plan geospatial objects classes that define the conceptual model of geospatial profile data sets; the profile of basic and additional metadata elements;

2) a database that includes: the geospatial data base of the master plan objects and the geospatial data base of zoning objects; a database of generalized indicators of structural and planning units, which provides the automatization of the process of determining technical and economic indicators; a library of SQL functions for methods that simulate the behavior of master plan objects and provide database integrity based on built-in functions of SQL language that meet the requirements of the Open Geospatial Consortium (OGC) specification [OpenGIS Implementation Specification for Geographic information – Simple feature access – Part 2: SQL option.] and the international standard ISO / IEC 13249-3: 2011. Information technology – Database languages – SQL Multimedia and Application Packages – Part 3: Spatial − 2012 [ISO/IEC 13249-3:2011].

As noted earlier, the modeling of the master plan objects behavior is implemented using the library of applied SQL-functions. The modeling of functional behavior of objects includes the following tasks: automatization of the determining process of the urban quality and technical and economic indicators of the territory, creation of urban objects, and determining the optimal location of objects. In general, object behavior modeling can be submitted as a processing system, which is defined as a set of input and output data, basic and applied spatial analysis, and modeling functions, with rules of interaction for the listed system components. The processing system of the modeling process of the MP objects behavior (S) can be defined as the following five elements:

$$S = \{Д_O, Д_R, F_O, F_A\}, \quad (1)$$

where $Д_O$ − a set of input data that includes spatial data G_O and non-spatial data C_O: $Д_O = G_O \cup C_O$; $Д_R$ − a set of resulting data that includes spatial data G_R and non-spatial data C_R: $Д_R = G_R \cup C_R$; F_O – basic functions of spatial analysis and modeling; F_A – applied functions of solving tasks of the territory planning, which implement the transformation of input data into the resulting data: $F_A = Д_O \rightarrow Д_R$ or $Д_R = F_A (Д_O)$; R – rules for defining scenarios for the basic functions use F_O in the system of modeling the behavior of master plan objects: R_i: $F_{Ai} = \{F_{Oj}\}$, where F_{Ai} – an applied function of object behavior modeling.

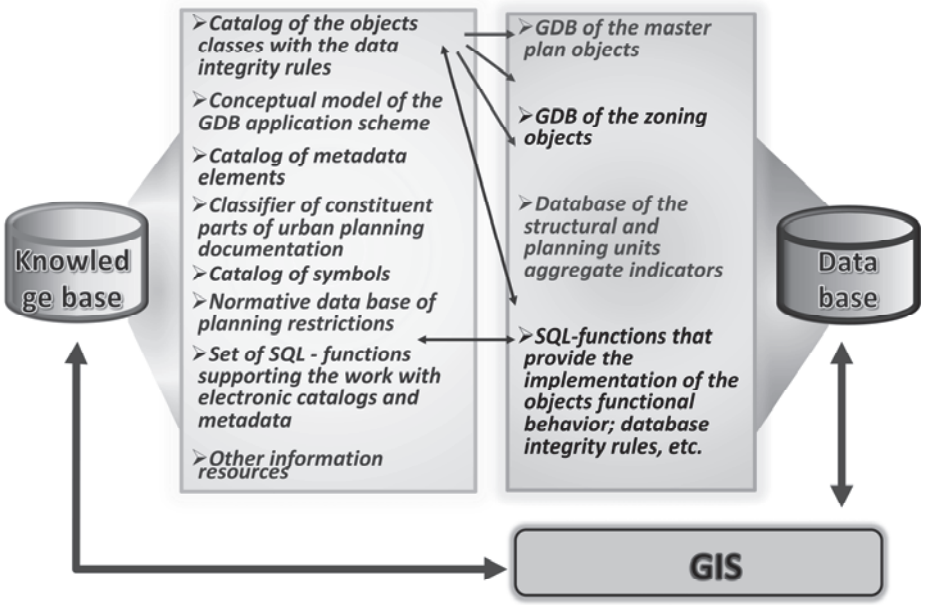

Fig. 3. Generalized structure of the master plan geospatial data OOM

Within a one publication, it is impossible to consider in details the methodology and implementation of the solution of master plan objects behavior modeling tasks. In the work of [Maksimova Yu., 2017] a methodology and an example of implementation of an automated process for determining the master plan technical and economic indicators are considered. In this publication in the "results", an example of implementation of automatization process of restriction zones creation is reviewed.

Results

The geoinformation technology of the geospatial profile data sets preparation is implemented in the DBMS PostgreSQL/postgis [https://www.postgresql.org/] and GIS QGIS [http://qgis.org/en/site].

For the production of graphic materials in the system knowledge base the rules of the master plan schemes digital models formation (section "Object composition model and mapping rules" in the technological scheme Fig. 2) based on the master plan objects geospatial data base (Fig. 4) are defined. On the basis of these rules, the patterns (templates) of the typical models for the spatial solutions representing in the form of the schemes required by DBN B.1.1-15: 2012, for example such as the plan of the existing use (Fig. 5), the scheme of the engineering equipment of the territory (Fig. 6) are formed.

The creation of the thematic zones relate to the tasks of spatial modeling of objects in GIS, namely, operations to determine the geometry of objects [Handbook of Applied Spatial Analysis Software Tools, Methods and Applications. Springer-Verlag Berlin Heidelberg 2010]. The method of formation of thematic zones geospatial data by means of GIS is considered inthe example of the restrictions zones. The restriction zones are preferably established as a certain buffer zones of normatively defined dimension relative to the boundaries of the territory or the constructive lines of artificial structures of regime objects (RO). For the implementation of automated creation of the restriction zones in the master plan geoinformation model, a formalized database of normative data (FDND) of planning restrictions based on regulatory documents, and technical regulationshas been developed regarding the requirements for the establishment of restriction zones around RO; a library of applied PL/pgSQL-functions, which implement the automatic process of creating, storing, and deleting restrictions zone in the FDND.

The generalized scheme of the realization of restriction zones creation process in the OR DBMS is set out in Fig. 7.

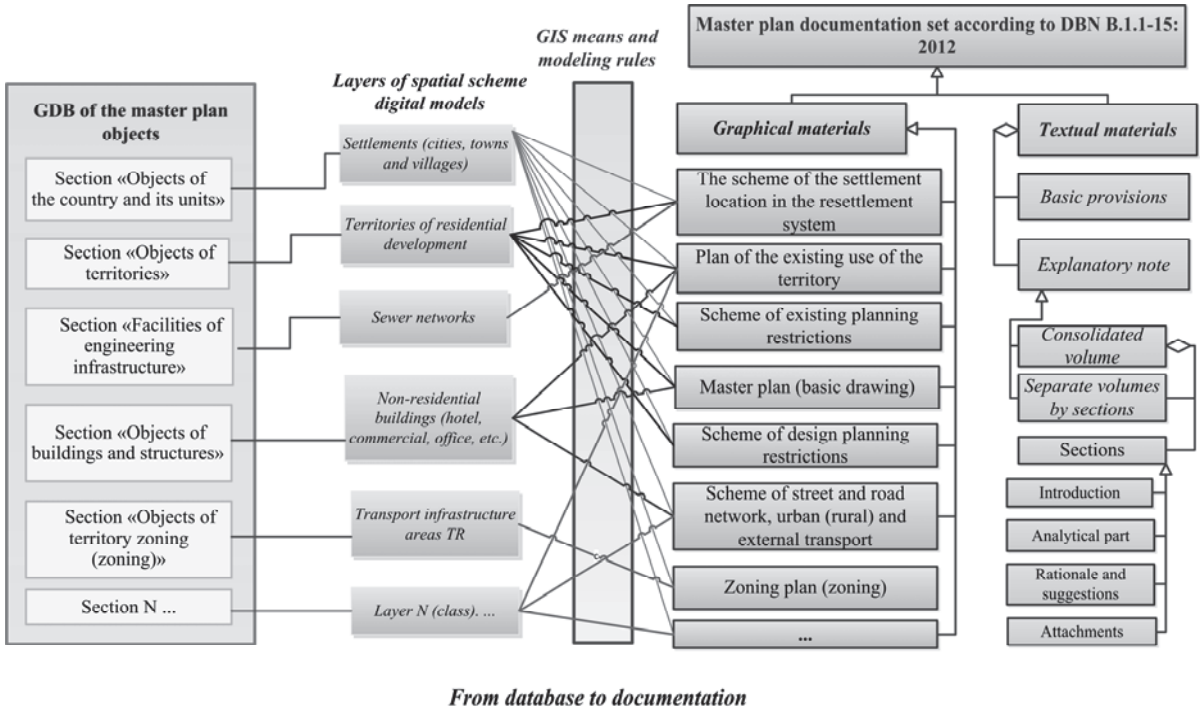

Fig. 4. Model of the master plan spatial schemes formation based on using GDB

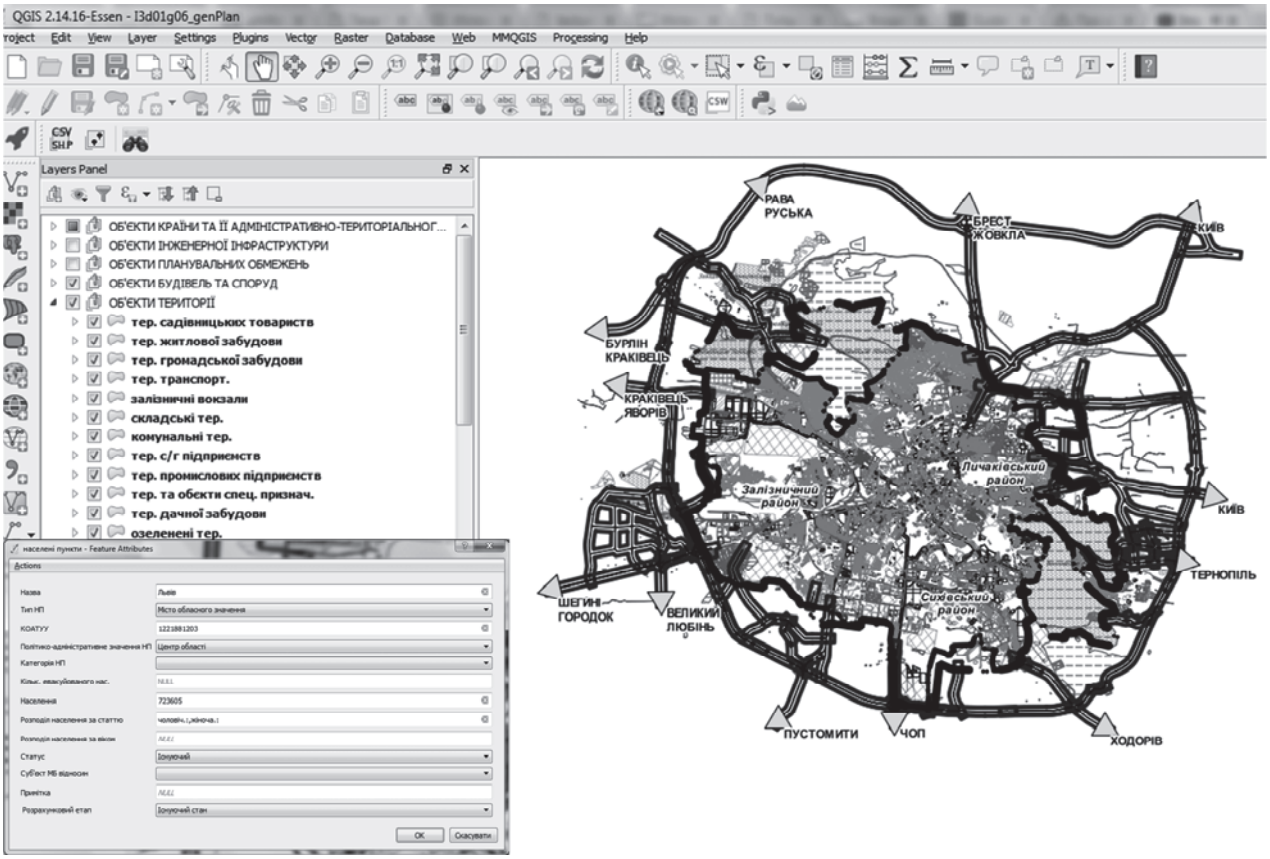

Fig. 5. A fragment of the master plan of the Lviv city in the QGIS (main drawing)

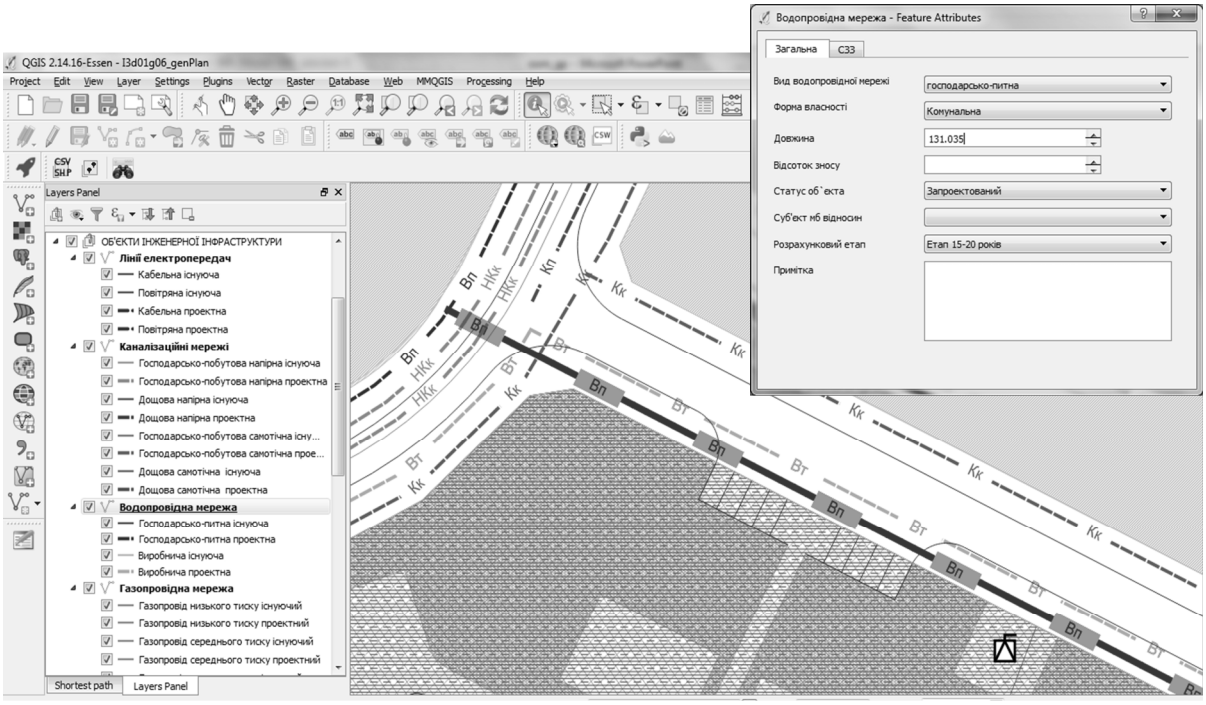

Fig. 6. Fragment of the master plan of the village Bobrytca in the QGIS (scheme of the engineering equipment of the territory)

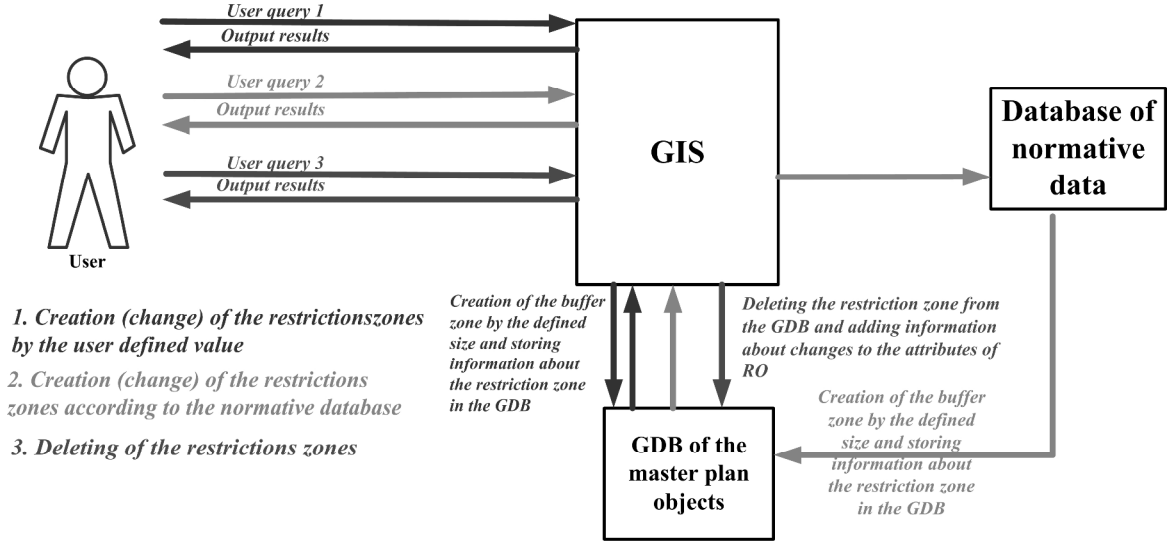

Fig. 7. The generalized scheme of the realization of automatic restriction zones creation process

Let's consider the physical implementation of the restriction objects creation on the example of sanitary protection zones (SPZ). The process involves the following steps (below a fragment of SQL-functions of the objects behavior modeling library is given):

1. Creation of a trigger SQL function for RO, which is responsible for creation or deleting the SPZ.

1.1 Creation of the function and declaration of the variables:

```
CREATE OR REPLACE FUNCTION law._add_new_resz_zone_ind()
RETURNS trigger AS
$BODY$
DECLARE v bigint; size real;_statmd bigint;_class_code text;
BEGIN
```

1.2 Defining the actions to be taken in a case of creation a new RO:

IF TG_OP = 'INSERT' THEN

1.2.1 Determining the size of the SPZ:

SELECT(CASE WHEN (new.regim_obj is true and (new.zon_size<>0)) THEN new.zon_size WHEN(new.regim_obj_doc is true and (new.type is not NULL)) THEN

(select zone_size from law.sys_san_prot_zone_class_view where id_code=new.type) END) into _size;

1.2.2 Creation of new SPZ:

INSERT INTO resz_zone(type, size, class, statmd, geom, moid_obj) VALUES (70311033,_size, CASE WHEN new.class IS NOT NULL THEN new.class ELSE (select class_code from law.sys_san_prot_zone_class_view where id_code=new.type) end ,new.statmd, st_buffer(new.geom,_size), new.moid);

RETURN NEW;

END IF;

1.3 Determining the actions that will be performed if the regime object is updated:

IF TG_OP = 'UPDATE' THEN

1.3.1 Deleting SPZ:

IF (old.regim_obj is true and new.regim_obj is false) OR (old.regim_obj_doc is true and new.regim_obj_doc is false) THEN DELETE FROM resz_zone WHERE moid_obj=new.moid and statmd=new.statmd; END IF;

1.3.2 Creating SPZ:

IF EXISTS (select * from resz_zone where moid_obj=new.moid and statmd=new.statmd) IS FALSE THEN select(case when (new.regim_obj is true and (new.zon_size<>0)) THEN new.zon_size WHEN(new.regim_obj_doc is true and (new.type is not NULL)) THEN (select zone_size from law.sys_san_prot_zone_class_view where id_code=new.type) end) into _size;

INSERT INTO resz_zone(type, size, class, statmd, geom, moid_obj) VALUES (70311033,_size, case when new.class is NOT NULL then new.class ELSE

(select class_code from law.sys_san_prot_zone_class_view where id_code=new.type) end ,new.statmd, st_buffer(new.geom,_size), new.moid);

RETURN NEW; END IF;

1.3.3 Updating SPZ:

IF EXISTS (select * from resz_zone where moid_obj=new.moid and statmd=new.statmd) is true THEN select(case when (new.regim_obj is true and (new.zon_size<>0)) then new.zon_size when(new.regim_obj_doc is true and (new.type is not NULL)) THEN (select zone_size from law.sys_san_prot_zone_class_view where id_code=new.type) end) INTO _size; UPDATE resz_zone SET geom=st_buffer(new.geom,_size),size=_size,class= new.class WHERE statmd=new.statmd and moid_obj=new.moid;

END IF; return new; END IF; RETURN NEW; END$BODY$ LANGUAGE plpgsql VOLATILE COST 1000;

2. Creating a trigger that causes a function law. add_new_resz_zone_ind():

CREATE TRIGGER _add_new_resz_zone

AFTER INSERT OR UPDATE

ON ter_production_territory

FOR EACH ROW EXECUTE PROCEDURE law._add_new_resz_zone_ind();

Scientific novelty and practical significance

In the publication the theoretical generalizations are done and practical results of solving the scientific and applied task of developing the methodological foundations of the master plan geospatial data object-oriented model for the increasing the efficiency of creating and using master plan geospatial profile data sets in the urban cadastre were obtained.

Conclusions

In the research the structure and components of the master plan geospatial data object-oriented model are determined, generalized scheme of the master plan geospatial profile data sets and master plan schemes formation based on the master plan geospatial data object-oriented model is proposed.

The usage of the object-relational model of geospatial profile data sets allow to provide not only independence from the GIS-platform, but also realize the transfer of knowledge transfer between different systems in the form of procedural functions.

Perspective directions for further research are the integration of GIS with urban monitoring data and other input sources and extension typical tasks to increase the level of automation of documentation preparation and decision making processes.

REFERENCES

A G-O Yeh. Urban planning and GIS. Geographical Information Systems, 62, 2005. Retrieved from: http://www.geos.ed.ac.uk/~gisteac/gis_book_abridged/files/ch62.pdf

Allen, S. Points and Lines: Diagrams and Projectsfor the City. / S. Allen– New York: Princeton Architectural press, 2009

Bretagnolle, A., Daude, E., Pumain. D.: From Theory To Modeling: Urban Systems As Complex Systems. CyberGe: European Journal of Geography, 2005, 355, 1–17 .

Formulation of gis based master plans for amrut cities. Design and Standards Ministry of Urban Development, 2016. Retrieved from: http://www.amrut.gov.in/writereaddata/designandStandards_AMRUT.pdf

Handbook of Applied Spatial Analysis Software Tools, Methods and Applications. Springer-Verlag Berlin Heidelberg 2010, p. 828. Manfred M. Fischer • Arthur Getis.

Horkovchuk, D. V. Rozroblennia geoinformatsiinoi modeli zonuvannia miskih teritorii dlia vykorystannia v systemah mistobudivnogo kadastru [Development of geoinformation model of urban territories zoning for use in urban planning cadastre systems]. *ScienceRise – ScienceRise*, 2016, no. 2 (29) [in Ukrainian].

Integrating geographic information systems and agent-based modeling techniques for simulating social and ecological processes /editor, H. Randy Gimblett p. cm — (Santa Fe Institute studies in the sciences of complexity) Includes bibliographical references and index. ISBN 0-19-514336-1; ISBN 0-19-514337-X (pbk.). p. 342, 2002 by Oxford University Press, Inc.

ISO/IEC 13249-3:2011 – Information technology– Database languages. SQL Multimedia and Application Packages. Part 3: Spatial, 2012.

Lyashchenko A. A. Systemni vymogy do suchasnogo mistobudivnogo kadastru ta mistobudivnoї dokumentatsiї [System requirements for urban cadastre and urban planning documentation]. *Mistobuduvannia ta teritorialne planuvannia − Urban and territorial planning*, 2013, no. 47, 397–405 [in Ukrainian].

Maksymova, Yu. S. Analiz modelei naboriv profilnyh geoprostorovyh danyh generalnyh planyv [Analysis of master plans profile geospatial data sets models]. *ScienceRise*, 2017, no. 7, 48–53 [in Ukrainian].

Maksymova, Yu. S. Obyektno-oriientovana model heoprostorovyh danyh heneralnoho planu. [Object-oriented model of master plan geospatial data]. *Upravlinnia rozvytkom skladnyh system − Management of Development of Complex Systems*, 2017, 31, 92100 [in Ukrainian].

OpenGIS Implementation Specification for Geographic information. Simple feature access. Part 2: SQL option.

Sait prohramnoho zasobu PostgreSQL. [Site of PostgreSQL software]. https://www.postgresql.org/. Retrieved from: https://www.postgresql.org/ [in Russian].

Sait prohramnoho zasobu QGIS. [Site of QGIS software]. http://qgis.org/ru/site. Retrieved from: http://qgis.org/ru/site [in Russian].

Sklad ta zmist heneralnoho plany naselenoho pynkty: DBN B.1.1-15:2012 від 2012.07.13. [DBN B.1.1-15:2012. Composition and content of the settlement master plan from 2012.07.13]. (2012). *Ministerstvo rehionalnoho rozvytku budivnitstva ta zhitlovoho komunalnoho hospodarstva − Ministry of Regional Development of Construction and Housing Utilities.* [in Ukrainian].

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ГЕОІНФОРМАЦІЙНА ТЕХНОЛОГІЯ РОЗРОБЛЕННЯ НАБОРІВ ПРОФІЛЬНИХ ДАНИХ ГЕНЕРАЛЬНИХ ПЛАНІВ

Мета. Метою дослідження є розроблення об’єктно-орієнтованої геоінформаційної моделі наборів профільних геопросторових даних генеральних планів населених пунктів. Актуальність дослідження зумовлена необхідністю задоволення сучасних вимог законодавства щодо розроблення в складі графічної частини документації генерального плану наборів профільних геопросторових даних та нагальністю завдань підвищення рівня автоматизації та рівня якості цифрових даних у складі генерального плану для їх подальшого ефективного використання в системі містобудівного кадастру. **Методика**. Основу методики розроблення геоінформаційної моделі генерального плану становить традиційний підхід до проектування бази даних (БД), що містить рівні концептуального, логічного та фізичного моделювання. Для концептуального моделювання використано уніфіковану мову моделювання UML (Unified Modeling Language), яку рекомендовано як основний засіб моделювання в комплексі міжнародних стандартів з географічної інформації/геоматики та програмний засіб, що підтримує інтерактивний режим створення UML-діаграм Visio. Для реалізації бази геопросторових даних генерального плану та поведінковий складової геоінформаційної моделі використано розширення стандартної мови SQL99 новим типом даних geometry та вбудованими функціями, що забезпечують зберігання, опрацювання і аналіз геопросторових даних

у реляційних системах керування базами даних. Запропоновані моделі в досліджені реалізовано в середовищі об'єктно-реляційної СКБД PostgreSQl/Postgis та геоінформаційної системи QGIS. **Результати**. Виконано типізацію моделей організації наборів профільних геопросторових даних (НПГД) у ГІС та обґрунтовано переваги застосування об'єктно-реляційної моделі даних для підготовки НПГД у складі генерального плану. Запропоновано та реалізовано технологічну модель формування наборів профільних геопросторових даних на основі бази геопросторових даних об'єктів генерального плану. Наведено приклад реалізації методів для автоматизованої побудови зон обмежень генерального плану з використанням SQL-функції. **Наукова новизна**. Розроблено модель формування наборів профільних геопросторових даних генеральних планів, яка основується на інтеграції об'єктно-реляційних баз даних та геоінформаційних систем та об'єктно-орієнтовану модель геопросторових даних об'єктів генерального плану, реалізація якої в середовищі ОР СКБД забезпечує незалежність даних від засобів та форматів інструментальних геоінформаційних систем. **Практична значущість**. Запропонована об'єктно-орієнтована модель геопросторових даних генерального плану забезпечує підвищення ефективності створення і використання наборів профільних геопросторових даних генеральних планів в містобудівному кадастрі.

Ключові слова: містобудівна документація; набори профільних геопросторових даних; генеральний план; об'єктно-орієнтована модель; база геопросторових даних.

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