CARTOGRAPHY AND AERIAL PHOTOGRAPHY

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INSPIREID IMPLEMENTATION IN THE TOPOGRAPHIC DATABASE
OF THE MAIN STATE TOPOGRAPHIC MAP OF UKRAINE

The article researches the principles of creation and assignment of a unique identifier inspireId to objects of classes in the topographic database (TDB), which is developed on the basis of the concept of model-driven architecture. The issue of automatic generation of a unique identifier inspireId and the rules of its life-cycle is researched. **The goal** of the work is to study the principles and requirements for the structure and assignment of a unique identifier inspireId objects of classes of TDB and the implementation of its automatic generation in SQL to provide interoperability with datasets of European Union Geospatial Data Infrastructure (INSPIRE) and EuroRegionalMap (ERM). **Methods.** In accordance with the general principles and requirements of the ERM to the structure of the unique identifier inspireId objects of classes of the topographic database, developed its structure for the identification of objects in the TDB "Main State Topographic Map". The function for automatic generation of inspireId in the object-relation database management system (ORDBMS) PostgreSQL has been developed. The life-cycle rules of a unique identifier in TDB, which ensures its stability, are considered in detail. **Results.** The developed structure of the unique inspireId identifier and the proposed rules of its life-cycle can be used in any geospatial databases. The use of the unique identifier inspireId in the Topographic Database "Main State Topographic Map" provides a link to the Infrastructure for Spatial Information in the European Community and EuroRegionalMap datasets. **Scientific novelty and practical significance.** The method of assigning a unique identifier inspireId to the objects of the topographic database classes "Main State Topographic Map" is proposed, which will further provide a link to the sets of the Infrastructure for Spatial Information in the European Community and EuroRegionalMap.

Key words: inspireId, unique identifier, geospatial database, topographic database, SQL, INSPIRE, ERM, geographic information systems, GIS, national spatial data infrastructure, NSDI.

Introduction

Within the framework of the project "Maps for good land governance", with the participation of the State Service of Ukraine for Geodesy, Cartography and Cadastre (SSGCC) and the Statens Kartverk (SK) – the Norwegian Mapping Authority, the topographic database "Main State Topographic Map" will be created. [Karpinskyi & Lazorenko-Hevel, 2019; Preparation works, 2019].

TDB "Main State Topographic Map" is the necessary component of the Core Reference dataset of the National Spatial Data Infrastructure (NSDI) of Ukraine to provide a single digital topographic basis (SDTB) for the entire country. According to the Law of Ukraine "On the National Spatial Data Infrastructure of Ukraine", which had been adopted on April 13, 2020, Core Reference data are the publicly available geospatial data, which form a unified digital coordinate-spatial basis for the production, integration and implementation of other activities with different geospatial data [The Law of Ukraine No. 2370, 2020].

NSDI of Ukraine will be integrated with INSPIRE datasets in the future, and the beginning of this process was established in the framework of the EuroRegionalMap (ERM) project, in which Ukraine is an active participant since 2019 [Elling & Reichelt, 2019].

Considering the rapid integration with pan-European geospatial datasets, topographic database "Main State Topographic Map" must take into account the required attributes that provide links between feature classes. It is also important to be able to identify the lineage of geospatial features in the TDB during its integration with the geospatial databases (SDB)

of other countries in accordance with the INSPIRE directive [Directive 2007/2/EC, 2007].

This role in INSPIRE datasets is performed by the stable complex key attribute *inspireId* (INSPIRE Unique Identifier) is an external identifier (not a thematic one), which uniquely identifies a spatial object related to a specific dataset, and should be generated automatically when the new feature class is created [Directive 2007/2/EC, 2007; INSPIRE Technical Guidelines, 2014; Elling R., 2020].

Problem formulation

To provide the implementation of the modern geoinformation approach to the creation of digital topographic maps and plans it is necessary to create the topographic database, which will be the core of topographic mapping. Such the geospatial database is created in the database management systems such as PostgreSQL and should not depend on instrumental geographic information systems (GIS). In this case, the digital topographic map in the formats of any GIS is the result of the request to the TDB.

The research [Karpinskyi, 2019] considers the stages of design of SDB and the requirements of its organization in accordance with the series of international standards ISO 19100 "Geographic Information/Geomatics", Open Geospatial Consortium (OGC), INSPIRE, ERM, national standards (DSTU) and standards of the Ministry of Agriculture Policy and Food of Ukraine (Ministry of Agrarian Policy. Now called the Ministry of Economic Development, Trade and Agriculture of Ukraine), as the central executive body in the field of topographic, geodetic and cartography activities (SOU) "The topographic database". The classes of features defined in the developed TDB [Karpinskyi et al., 2019], contain the *inspireId* attribute, which ensures the uniqueness of features in geospatial databases.

According to the INSPIRE [Directive 2007/2/EC, 2007], feature identifiers of the geospatial database must ensure the performance of the following tasks:

– definitely identify and track geospatial features in data sets;

– to be able to manage the life-cycles of geospatial features, including their version;

– to provide the possibility of their reuse to organize the connection of geospatial data with other information.

Peculiarity of the implementation of *inspireId* in Ukraine needs a separate study due to the new concept of geospatial data production.

Analysis of recent research

The principles and general regulations which are the basis of development SOU "The topographic database" are defined in the research [Karpinsky et al., 2010]. One of them is the completeness of feature identification when each feature is assigned a unique topographic identifier – TOID, and code according to the relevant industry classifier if the following exists. [Jakobsson & Ilves, 2016; Karpinskyi et al., 2010]. It should be noted that the TOID is used as a unique identifier, which consists of the letters "osgb" and 16-character code and is assigned to each feature class in the topographic database, which provides the uniqueness of national data. [OS MasterMap, 2019; Craglia, 2002; Heipke та ін., 2003; Lüscher, 2011].

In the scientific article [Reitz, 2018] specifics of identifiers are researched: *gml:id*, *gml:identifier* and *inspireId*, which are attributes of data set classes INSPIRE, the linage and functions of these identifiers are determined, it is noted that the creation of stable identifiers that can be referenced is difficult, but possible. In the specifications INSPIRE indicates that the *inspireId* attribute has an Identifier data type and is a concatenation of three attributes [INSPIRE Technical Guidelines, 2014]:

$$\langle namespace \rangle : \langle localid \rangle ; \langle beginLifespanVersion \rangle$$

where *<namespace>* – namespace;

<localid> – local identifier;

<beginLifespanVersion> – the beginning of the life-cycle of the feature (date of creation or editing of the feature). The ERM technical documentation [Elling, 2020] is provided with the detailed description of the properties of the key attribute *inspireId*, as well as with solutions for the creation of this identifier, taking into account the location of the feature, the existing international or national identification system of features of the dataset. In the EuroRegionalMap datasets there are two mandatory attributes for feature identification of spatial classes:

1) *inspireId*;

2) *beginLifespanVersion*.

Those countries that have implemented *inspireId* in their national datasets provide them to ERM technical managers.

To achieve a harmonized system of unique identifiers (UID) in Europe, the developers of EuroGeographics have proposed a structure of the unique identifier *inspireId* (Fig. 1).
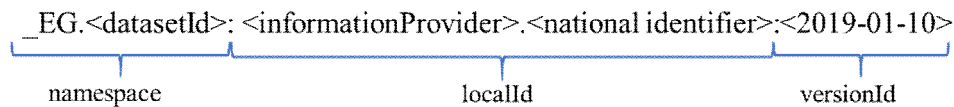
_EG.<datasetId>: <informationProvider>.<national identifier>:<2019-01-10>

namespace   localId   versionId

Fig. 1. The structure of the unique identifier inspireId in EuroGeographics

Fig. 1 shows the following values for example:_

– *EG* – the official abbreviation for EuroGeographics as a data provider;

– *<datasetId>* – data sources provided by the supplier;

– *<informationProvider>.<nationalidentifier>* – serial 6-character number or national code;

– *versionId* – the date creation or edition of the spatial feature or edited in the SDB class.

For geospatial features that are completely located within the country, the national code is accepted, if it is official. If this code cannot be provided to the data provider, *<localId>* is generated as a serial number.

If a geospatial feature is located in more than one country, such as river streams, executors use the centralized identification service in the ERM to avoid duplication of identifier values.

Thus, in recent studies and technical documentation [Elling, 2020; Jakobsson & Ilves, 2016; Karpinskyi et al., 2010, Craglia et al., 2002; Heipke et al., 2003; Lüscher, 2011] on automatic generation *of inspireId* in SQL and preservation of its life-cycle in SDB is not enough considered. Functions for automatic generation of such an identifier are described only conceptually [INSPIRE Technical Guidelines, 2014; Elling, 2020].

Results

To develop the *inspireId* generation function, it is necessary to research in more detail the structure of this identifier.

According to the technical documentation ERM [Elling, 2020] *inspireId* consists of the following attributes:

– A namespace <namespace> to identify the data sources. The namespace value shall be owned by the data provider of the spatial feature and shall be registered in the INSPIRE External Object Identifier Namespaces Register.

– A local identifier *<localId>*, assigned by the data provider. The local identifier is unique within the namespace, i.e. no other spatial object carries the same unique identifier.

– A version Id is the identifier of the spatial feature *<beginLifespanVersion> (<versionId>)*, with the maximum length of 25 characters and includes life-cycle information. A version Id identifier is used to distinguish between the different versions of a spatial feature and is unique.

For attribute values: *<localId>* and *<namespace>* shall only use the following set of characters: {"A" ... "Z", "a" ... "z", "0" ... "9", "_", ".", "-"}, that is only letters from the Latin alphabet, digits, underscore, point, and dash are allowed.

There are four requirements for *inspireId*:

1) Uniqueness. No two spatial features of spatial features types specified in INSPIRE application schemas may have the same external feature identifier, i.e., *inspireId* has to be unique within all the spatial features published in the geospatial database.

2) Persistence. The identifier has to remain unchanged during the lifetime of a spatial feature.

3) Traceability. Since INSPIRE assumes a distributed, service-based spatial data infrastructure (SDI), a mechanism is required to find a spatial feature based on its identifier. That is *inspireId* has to provide sufficient information about the source of the spatial feature so that arrangements can be made that allow to determine the download service(s) providing access to data from that source**.**

4) Feasibility The system has to be designed to allow the *inspireId* under existing national identifier systems can be mapped.

Considering the requirements to *inspireId*, a solution for the topographic database identifier has

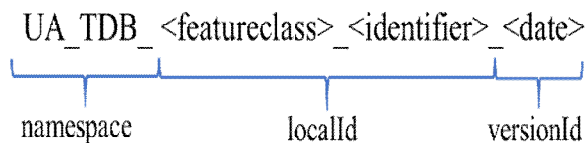been developed "Main State Topographic Map" (Fig. 2).

UA_TDB_<featureclass>_<identifier>_<date>

namespace   localId   versionId

Fig. 2. The structure of a unique identifier inspireId in the TDB

In the TDB, the unique identifier has the following structure:

– "*UA_*" – an abbreviation of the state as the administrator of data on the feature in accordance with ISO 3166-1 alpha-2;

– "*TDB_*" – an abbreviation of the topographic database, which was introduced by the authors in the works [9, 10];

– *<featureclass>* – the abbreviation of the spatial class in which the feature was created;

– *<identifier>* – serial 35-character number for national code;

– *<date>* – the date creation of the spatial feature class in the TDB.

This structure of the identifier allows to determine the territorial affiliation of the feature, its linage and version, as well as uniqueness not only within the class but also the data set.

The function for automatic generation of *inspireId* was developed in the object-relational database management system (ORDBMS) PostgreSQL (рис. 3).

```
Query Editor    Query History

1    CREATE OR REPLACE FUNCTION metadata.inspierid()
2        RETURNS character varying
3        LANGUAGE 'plpgsql'
4
5        COST 100
6        VOLATILE
7
8    AS $BODY$
9    DECLARE
10
11       inspierid varchar;
12
13 ▼  BEGIN
14
15   inspierid=(select 'UA_'||'TDB_'||'ADR_'||CAST(uuid_generate_v1() AS varchar(16))||
16           nextval('metadata.cls_clsid_seq')||'_'||now());
17       raise notice 'result (%)', inspierid;
18       return inspierid;
19
20   END;
21   $BODY$;
22
23   ALTER FUNCTION metadata. inspierid()
24       OWNER TO postgres;
```

Fig. 3. Function for automatic generation inspireId in the TDB

Punctuation between attributes in *inspireId*: "." (dot) and ":" (colon) have been replaced by "_" (underlining) because the first characters are used as service characters in operating systems.

To modify or create *inspireId* as a result of queries (update, delete, create) or geospatial analysis (merge, intersection, etc.) in the TDB formed the list of rules of the life-cycle of the

identifier, the status of which is defined in the scientific work (Table. 1) [Elling R., 2020].

To describe an example of the structure of *inspireId* and the application of the rules of its life-cycle in the TDB, consider the feature "River" segment "Hydrography and hydraulic structures", which corresponds to the code of the topographic feature "31410000".

Life-cycle rules *inspireId* in the TDB

Status	The name of the operation	Rule
Mandatory	Creation of the feature class	*inspireId* = new value; *<date>* = creation date of the feature
Mandatory	Simple feature modification (geometric and/or semantic)	*inspireId* does not modify; *<date>* = edition date of the feature
Mandatory	Editing spatial feature class (changing the class name or spatial localization type)	*inspireId* = new value; *<date>* = creation date of the feature
Optional	Split the feature in two or more	*inspireId* of the feature 1 does not modify; *inspireId* of the feature 2 = new value; *<date>* = edition date of the feature
Optional	Merge	the resulting feature gets the value *inspireId* of one of the source features; *<date>* = edition date of the feature

Figure 4 shows three geospatial features created in the TDB with the following identifiers *inspireId*:

– UA_TDB_HYDRO_9c0e504a-9449-100001_2020-04-13;

– UA_TDB_HYDRO_9c0e504a-9449-100002_2020-04-13;

– UA_TDB_HYDRO_9c0e504a-9449-100003_2020-04-13.

Figures 5 and 8 show life-cycles *inspireId* in the TDB. ERM developers recommend that in case of differences in the optional rules for creating and modifying an *inspireId* in the geospatial database, all cases should be documented in the class or dataset metadata.

For automatic execution of these rules, in the TDB will develop trigger functions that make changes to the feature of the class after the ID is created or edited.

Scientific novelty and practical significance

The method of assigning the unique identifier *inspireId* to the features of the topographic database classes "Main State Topographic Map", is proposed, which will further provide the link to the sets of the Infrastructure for Spatial Information in the European Community and EuroRegionalMap.

The developed structure of the unique identifier *inspireId* and the proposed rules of its life-cycle can be used in any geospatial databases.
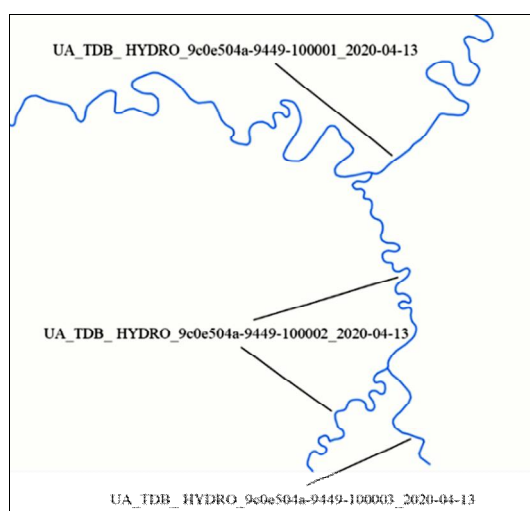

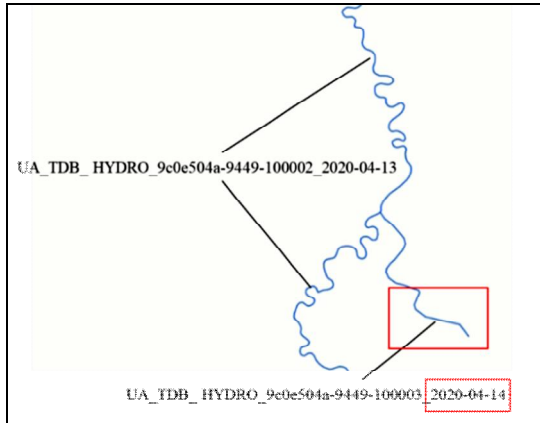*Fig. 4. Example rule in case of creation the feature of the class in the SDB*

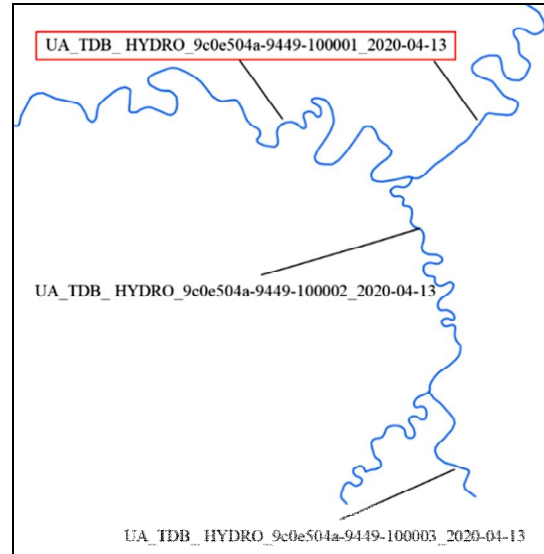*Fig. 5. Example rule in case of edition
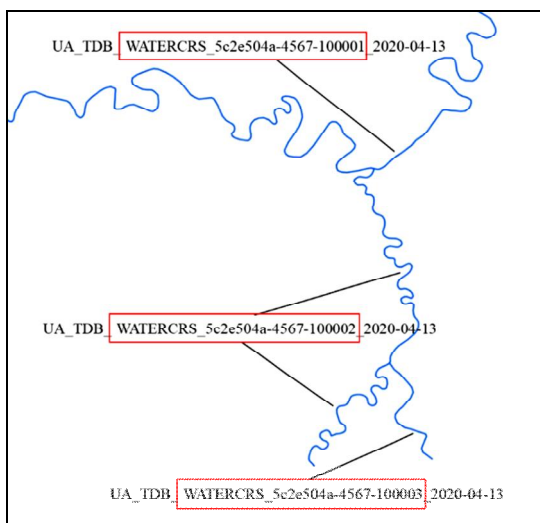the feature of the class in the SDB*

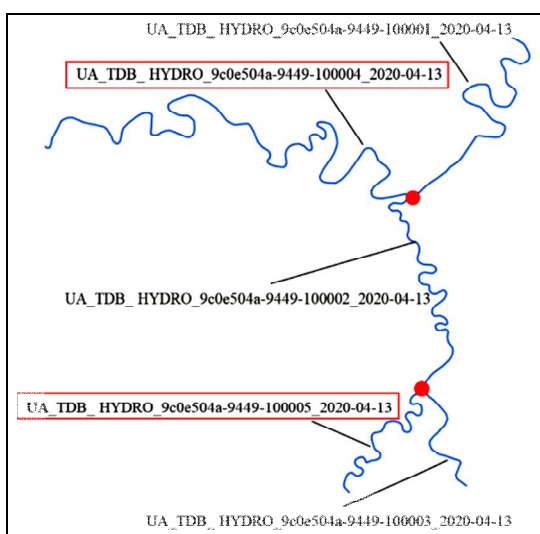*Fig. 6. Example rule in case
of edition the feature class in the SDB*

*Fig. 7. Example rule in case of feature split
the feature in two or more in the SDB*

*Fig. 8. Example rule in the case
of merging features of the class in SDB*

Conclusions

In accordance with the general principles and requirements of ERM to the structure of the unique identifier *inspireId* and to the features of the topographic database classes, its structure has been developed to identify the features of the TDB "Main State Topographic Map".

The function for automatic generation of *inspireId* in the ORDBMS PostgreSQL has been developed. The life-cycle rules of the unique identifier in TDB, which ensures its stability, are considered in detail.

The use of the unique identifier *inspireId* in the Topographic Database "Main State Topographic Map" provides a link to the Infrastructure for Spatial Information in the European Community and EuroRegionalMap sets.

To provide the official status of the identifier of geospatial features and its implementation for using in the National Spatial Data Infrastructure it is necessary to take into account the requirements for

the identifier during the preparation of the specification of the topographic database and the Procedure for the administration of NSDI.

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ВПРОВАДЖЕННЯ INSPIREID У БАЗІ ТОПОГРАФІЧНИХ ДАНИХ ОСНОВНОЇ ДЕРЖАВНОЇ ТОПОГРАФІЧНОЇ КАРТИ УКРАЇНИ

У статті досліджуються принципи побудови та присвоєння унікального ідентифікатора *inspireId* об'єктам класів у базі топографічних даних (БТД), яку розроблено на основі концепції модельно-керованої архітектури. Досліджується питання автоматичної генерації унікального ідентифікатора *inspireId* та правила його життєвого циклу. Метою роботи є дослідження принципів та вимог до структури і присвоєння унікального ідентифікатора *inspireId* об'єктам класів БТД та реалізація автоматичної його генерації у мова структурованих запитів (SQL) для забезпечення зв'язку з наборами Інфраструктури геопросторових даних Європейського Союзу (Infrastructure for Spatial Information in the European Community – INSPIRE) та EuroRegionalMap (ERM). Відповідно до загальних принципів та вимог ERM до структури унікального ідентифікатора *inspireId* об'єктам класів бази топографічних даних, розроблено його структуру для ідентифікації об'єктів БТД "Основна державна топографічна карта". Розроблено функцію для автоматичної генерації *inspireId* у середовищі об'єктно-реляційної системи керування базами даних (ОР СКБД) PostgreSQL. Детально розглянуто правила життєвого циклу унікального ідентифікатора у БГД, що забезпечує його стабільність. Використання унікального ідентифікатора *inspireId* у Базі топографічних даних "Основна державна топографічна карта" забезпечує зв'язок, з наборами Інфраструктури геопросторових даних ЄС та EuroRegionalMap.

Ключові слова: inspireId, унікальний ідентифікатор, база геопросторових даних, база топографічних даних БТД, SQL, INSPIRE, ERM, геоінформаційні системи, ГІС, національна інфраструктура геопросторових даних, НІГД.