GIS Odyssey Journal

2023 • Volume 3 • Number 1

https://doi.org/10.57599/gisoj.2023.3.1.5

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USE OF UNIVERSAL ADDRESS TO ENSURE HIGH – QUALITY DATA

Abstract: The article describes how to ensure high quality of data previously processed in silos, i.e. separate databases and central registers. The concept of using a universal address was created in Poland in 2017, it was tested in practice and recommended for use in the annex to Resolution No. 28 of the Council of Ministers of February 18, 2021 on the Data Opening Program for the years 2021–2027 (Monitor Polski 2021, item 290). It is based on a specific complex data – created automatically and also automatically used, built from legally authorized codes – the so-called universal address. It is appropriate for solutions used in Poland because it is based on codes created by the Central Statistical Office and data structures of the Central Office of Geodesy and Cartography. It seems, however, that the concept is universal and could also be used in other countries and places where silos – not having a direct connection with each other – contain theoretically the same data provided with specifically defined identifiers. The practical usefulness of the described solution justifies an attempt to popularize it more widely and use it in various forms. The purpose of this article is to present this concept and to discuss it.

Keywords: data quality, open data, territorial codes, geodetic coordinate system, universal address, data integrity

Received: 11 April 2023; accepted: 17 May 2023

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Introduction with analysis of the state of the problems

Data in legal circulation should be up-to-date and verifiable. Especially when it is data on which human safety depends (Wojsyk, 2019). The purpose of this article is to draw attention to the currently existing technical possibilities of detecting inconsistencies in address data contained in separate silos.

In Poland, as elsewhere, information silos are usually created in separate areas, managed by the minister or the head of the central office on the basis of separate legal provisions specifying in detail the scope, type and format of the collected data and the entities managing these silos. In this article, the possibility of capturing discrepancies between the same (theoretically) data stored in two different registers is shown.

Thanks to the use of linking territorial codes with geodetic data in the structure called "universal address", it is possible to automatically detect inconsistencies in data stored in the dictionaries of the Central Statistical Office (GUS) and in local resources created in communes, and then centralized in the Central Office of Geodesy and Cartography (GUGiK). Data inconsistency indicates an error made by a human (*errare humanum est*) manually entering data into each of these systems. Anyone using open resources (and these include both dictionary data provided by GUS and data provided by GUGiK) can create an appropriate, convenient solution for them, allowing them to determine which of the shared data are correct, consistent and which are uncertain and need checking.

The solution referred to in this article was created in mid-2017 (Wojsyk K., 2018, Adres …) as a response to the need to determine the real addresses of medical entities and pharmacies, in connection with the finalization of the creation of the healthcare information system (SIM), and in particular the system of electronic prescriptions. Prescriptions must contain the address of the medical entity where the prescription was issued – and it cannot be a non-existent (unverifiable) address. A universal address turned out to be a helpful solution.

The universal address is created automatically on the basis of territorial codes contained in the State Border Register (PRG) and dictionary data contained in the TERYT register. If the technical possibility of reaching into the silos and confronting the data contained therein is not created, the universal address will not be properly constructed. The essence of the concept boils down to creating the possibility of automatically generating reports of data inconsistencies, so that a human official can notice these inconsistencies and react appropriately.

The concept described in this article has been tested in Poland in practice: in the "*polska.e-mapa.net*" system, in the "*schematyzm.katolicki.pl*" application and in the so–called "address verifier" (available until December 9, 2022) at https://itia.pl/adres. It can be applied by others.

Material and methods

In 2017, the co-author of this article (K. Wojsyk), while working at the Center for Healthcare Information Systems (currently the e-Health Centre) in Warsaw, noticed the

phenomenon of the deterioration of the quality of data in medical registers (registers of pharmacies, entities performing medical activities, etc.). It was noticeable that the addresses of some of the above–mentioned entities (pharmacies, doctor's offices, clinics, etc.) entered in the register did not comply with the current address data, although the entities themselves did not physically change their location. Starting from January 3, 2021, every Saturday, K. Wojsyk was downloading data from the TERYT and PRG registers and comparing them using his own tools (programs written by himself) and Excel (used only for presentation), in order to detect data discrepancies in both registers. The question arose whether it was possible to create a mechanism to **automatically** update street names in other registers (information silos) based on the source of changes. This article is a result of the abovementioned weekly data analysis and practical experience in working on data quality and with data registers (Wojsyk K., 2021). Again, the problem of data incompatibility and the possibility of using a universal address in the practice of local government was described in the article *Universal Address in Practice* (Wojsyk K., 2022).

Results and discussion

A closer look at the various cases of changes in the addresses of entities' locations revealed that there are two types of address changes. One of them results from the actual change of the entity's location – moving it by the owner to a different geographical location – to a different street, to a different building number (e.g. to a newly created shopping mall). However, these were rare cases. A definitely more frequent case was the change of the name of the street as a result of the Act of 1 April 2016 on the prohibition of propagating communism or other totalitarian system by the names of organizational units, auxiliary units of the commune, buildings, public utility facilities and equipment, and monuments (Journal of Laws of 2018, item 1103, consolidated text). It should be noted that the change of, for example, the name of a street was made without any participation of the owner of the medical entity, however, it forced him to report changes to the relevant register.

I. Register of the official territorial division of the country (TERYT) – first data silo. Changing the name of the street by the Commune Council involved the owner of the entity in activities independent of him and completely unnecessary from the technical point of view. Since everything – the name of the entity, its address and all other data is stored in electronic registers, it is (technically) possible to create a situation where a change in data in one place (the source place) will automatically cause changes in all other dependent places. However, there was a problem of silosity and the inability to transfer these changes. Considering the simplest case – changing the name of a street requires the adoption of an appropriate resolution by the Commune Council and the publication of the resolution in the Provincial Official Journal. There is a problem: entrepreneurs or, for example, natural persons residing on a given street may not find out about the change at all in due time – reading the announced provisions of law is not a typical everyday activity – and if they finally find out, they have to undertake

notification activities (in various time and in various ways) about the change, towards any entities with which they enter into relations requiring providing the address of their business activity.

The contents of the resolutions on changing the names of streets (squares, parks, housing estates, etc.) announced in the Provincial Official Journals constitute the basis for the Central Statistical Office (GUS) to create a facility code if the given name does not yet appear in the register. GUS creates facility codes based on the provisions of a) the Act of June 29, 1995 on public statistics (Journal of Laws of 2020, item 443, as amended) and b) the Regulation of the Council of Ministers of December 15, 1998 on detailed rules for keeping, using and making available the national official register of the country's territorial division and the related obligations of government administration bodies and local government units (Journal of Laws No. 157, item 1031, as amended). Thus, we are dealing with the TERYT register – which contains (appropriately marked with the dates of entry into force and cancellation) the names of objects with their codes. It should be emphasized that the code is assigned to the full name of the street – along with its feature, i.e. the type of facility. This means that the difference of even one character in the full name – and not only in sound, but even in the case of the letter or feature of the object – results in assigning a separate code. It is worth noting that this approach allows to work only with object name codes, instead of just names.

If in any system the name of an object appeared, which did not correspond to the code assigned by the authority appointed for this purpose, it would mean that the given name is incorrect, legally unenforceable.

Table 1 shows examples of names of objects listed on April 15, 2023 in the TERYT register, whose patron is a person named "Chopin", and their codes. Subsequently, from the left, the table contains object codes, feature, part of the name used for alphabetical sorting, the remaining part of the name and the merged name.

The assumption was that the division of names into parts was to enable the alphabetical ordering of the names of objects in various intended for reading directly by a human. Name changes are made almost daily (names are removed, added, changed). Irrespective of the system containing current names, the Central Statistical Office keeps a register of changes, containing the names before the change, the name of the place where the name was changed, the name after the change, the date from which the new name is effective and the appropriate name codes.

Summarizing, there is a legally mandated, public central register containing all current and obsolete object names and unique codes of these names. If there is an error in this register (e.g. a so-called misspelling, transposition, omission or other defect), until it is noticed, it will be able to replicate itself in all places where the given name is retrieved.

Table 1. Examples of various objects with "Chopina" in their name

SYM_UL	CECHA	NAZWA_1	NAZWA_2	NAZWA_PEŁNA
55337	al.	Aleja Chopina		al. Aleja Chopina
44073	ul.	Aleja Fryderyka Chopina		ul. Aleja Fryderyka Chopina
60628	al.	Aleja Fryderyka Chopina		al. Aleja Fryderyka Chopina
02842	park	Chopina		park Chopina
02843	pl.	Chopina		pl. Chopina
02844	ul.	Chopina		ul. Chopina
02846	park	Chopina	Fryderyka	park Fryderyka Chopina
02847	pl.	Chopina	Fryderyka	pl. Fryderyka Chopina
02849	ul.	Chopina	Fryderyka	ul. Fryderyka Chopina
33732	ul.	Chopina	F.	ul. F. Chopina
49650	ul.	Chopina	Fr.	ul. Fr. Chopina
02850	ul.	Chopina Boczna		ul. Chopina Boczna
48894	ul.	Chopina Fryderyka		ul. Chopina Fryderyka
51745	ul.	Osiedle Fryderyka Chopina		ul. Osiedle Fryderyka Chopina
55123	ul.	Park Fryderyka Chopina		ul. Park Fryderyka Chopina
31905	park	Park im. Fryderyka Chopina		park Park im. Fryderyka Chopina
55905	park	park im. Fryderyka Chopina		park park im. Fryderyka Chopina
50575	park	park imienia Fryderyka Chopina		park park imienia Fryderyka Chopina
60832	pl.	Pl. Fryderyka Chopina		pl. Pl. Fryderyka Chopina
40873	pl.	Plac Chopina		pl. Plac Chopina
50857	ul.	Plac Chopina		ul. Plac Chopina
43037	ul.	Plac Fryderyka Chopina		ul. Plac Fryderyka Chopina
48033	pl.	Plac Fryderyka Chopina		pl. Plac Fryderyka Chopina
43918	rondo	Rondo Fryderyka Chopina		rondo Rondo Fryderyka Chopina
44531	skwer	Skwer Fryderyka Chopina		skwer Skwer Fryderyka Chopina

Source: TERYT

II. **State Border Register (PRG) – second data silo.** The PRG register is also an open, public central register, made available by the Head Office of Geodesy and Cartography (GUGiK). Access to data and specific services is possible via the website https://geoportal.gov.pl. The specificity of this register is the fact that it contains so much data allowing to depict on maps (many different – including topographic and orthophotomaps) objects such as buildings, roads, road infrastructure objects, etc., that its use (despite opening the data) can be very difficult for non–geodesists.

The PRG, containing data sent electronically from commune offices, also includes the names of the objects of territorial division of the country and codes of names (this is required by law – the executive acts to the Act of May 17, 1989 Geodetic and Cartographic Law: Regulation of the Minister of Development, Labor and Technology of

July 21, 2021 on the register of towns, streets and addresses and Regulation of the Minister of Development, Labor and Technology of July 27, 2021 on the register of land and buildings), but there is a problem whose solution – although it seems simple – is only in the initial phase.

The essence of the problem lies in the different ways of sending data to central registers, these information silos. In the case of the first silo (TERYT), the name of the facility is created in the commune, published in the Provincial Official Journal, entered into the TERYT register – and also published – this time not in the form of a resolution, but in the form of data in the register – as a name supplemented with a code.

In the case of the second silo (PRG), the name created in the commune, after being entered into the commune geodetic system together with the code assigned by GUS, is sent in a strictly defined structure to the central register (PRG). This is where the "weakness" of the system occurs: an employee of the municipality sending data to the central register may make a mistake, forget to enter new data, mistakenly associate the code with the name, etc. Such an error in the local system is almost undetectable. The only chance is to confront what is in the name register (TERYT) – that is, a data pair = code+name, with the data sent to PRG – that is, to compare theoretically the same values from two silos. Any difference in values will indicate not so much an error as a discrepancy. In order to determine which of the two compared values is incorrect (if they are different), a comparison should be made with the model, which is the entry of the name of the facility in the local law act – the resolution of the Commune Council.

In almost 100% of cases, the entry in the TERYT register is consistent with the wording of the entry in the resolution of the Commune Council. The figure below shows the place (Verifier) where one can compare data from two silos – and report any discrepancies.

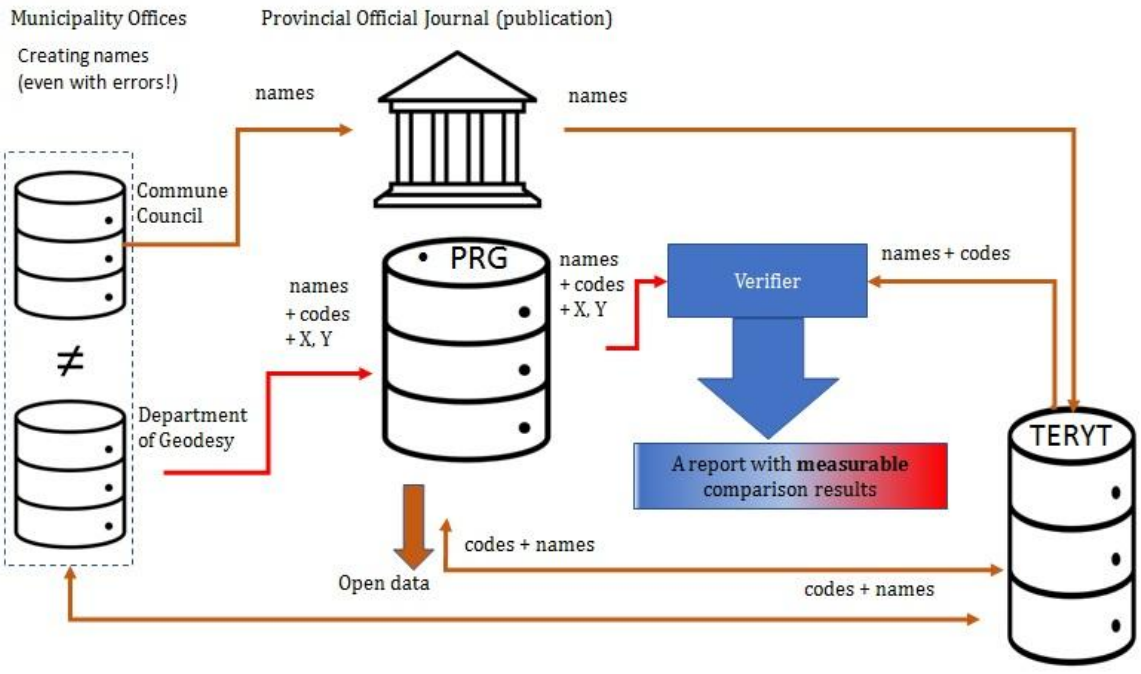

Figure 1. Confrontation of names and codes from two silos
Source: Kajetan Wojsyk, own chart

However, this does not fully solve the problem. There are cases (e.g. the capital city of Warsaw) where there are objects with the same names in the same city, but physically located in different places. Such locations are determined by the geodetic coordinates of the points – x, y in the rectangular system – and the above-mentioned legal provisions describe the method of determining them, e.g. for a building. Therefore, if there is a case of identically sounding addresses specifying different locations, then if they are associated with geodetic coordinates, it will always be possible to clearly determine which location is in question. However, such a solution is appropriate to be used for an IT system – people do not naturally transfer numerical coordinates to each other, they always use names. Therefore, it was necessary to create a solution that would contain something in a format suitable for human use, and something for a machine (IT system) – codes. Finally, as a result of the analyzes carried out, as well as taking into account various special cases, a structure was created that is constructed automatically, based on the TERYT dictionary and the x, y coordinates of the so-called address point (not to be confused with an address), additionally supplemented with a postal code.

According to the definitions given in the above-mentioned Regulation on the register of towns, streets and addresses:

address – an unambiguous description of the facility, carried out by indicating the town, postal code and street or square and the serial number at this street or square, and if there are no names for streets or squares in the town, the serial number in the town;

address point – address together with its spatial location expressed by flat rectangular x, y coordinates.

Therefore, the operation of coding an address point can be carried out by collecting in one specific structure TERYT codes (GUS), X, Y coordinates (GUGiK), the postal code appropriate for a given address point and finally the number of the building to which the description applies. It should be emphasized that since we are talking about a "point", it can mean the location of a lamppost, electrical substation, park bench, sewage well, fountain, bridge, tree, monument – anything that for some reason requires "addressing" for various purposes and visualizing on the map.

However, this structure, called the universal address, must be legible for humans in their human understanding. Therefore, it must be decoded – codes using the TERYT dictionary are "translated" into corresponding names, X, Y coordinates place on the map a specified point locating the object described with a universal address – and thanks to this operation, the location of the object becomes unambiguous.

But how does the encoding – the creation of a universal address – take place? If it is created by a man "by hand", he can do it in at least 2 ways:

1) Using an application based on dictionaries (updated daily) – selecting names from the list, from general to specific: voivodeship, city, street, building number. The choice of the county (*powiat*) is omitted because a person does not always have such a deep knowledge of the structure of the country's territorial division

to be able to distinguish, for example, the Częstochowa township (*powiat grodzki*) from the Częstochowa country district (*powiat ziemski*). However, when there is a situation of more than one town with the same name in a given province (voivodeship, *województwo*), the system will display a list of counties and communes (*gmina*) – and such a detailed list causes a moment of reflection – and then choosing the right town is easy. If there are no streets in a given town – then "none" is selected. After such selection, a list of formally existing, i.e. registered in the commune office, address points is displayed. If the number in question is not on the list, the situation requires clarification at the commune office.

2) By pointing to the map in a system that allows the so-called "reverse geocoding" a specific address point. The system – after clicking – saves the x and y coordinates of a point located on a specific street, in a specific town, in a specific commune (*gmina*), county (*powiat*) and province (*województwo*). This allows the code to be built automatically.

If the universal address is created by an IT system, it is done *en masse* on a national scale by collecting in a way suitable for direct use all universal addresses – in one file, containing also human-readable text data in the same record.

Below is an example of a record containing a postal code, territorial codes and rectangular coordinates of the location of the Monument to European Geodesy (*pomnik Geodezji Europejskiej*) at Theatre Square (*Plac Teatralny*) in Warsaw (see https://jbc.bj.uj.edu.pl/dlibra/doccontent?id=537965):

00077|146501|0918123|0918123|38515|488338|637132|, pomnik Geodezji Europejskiej|

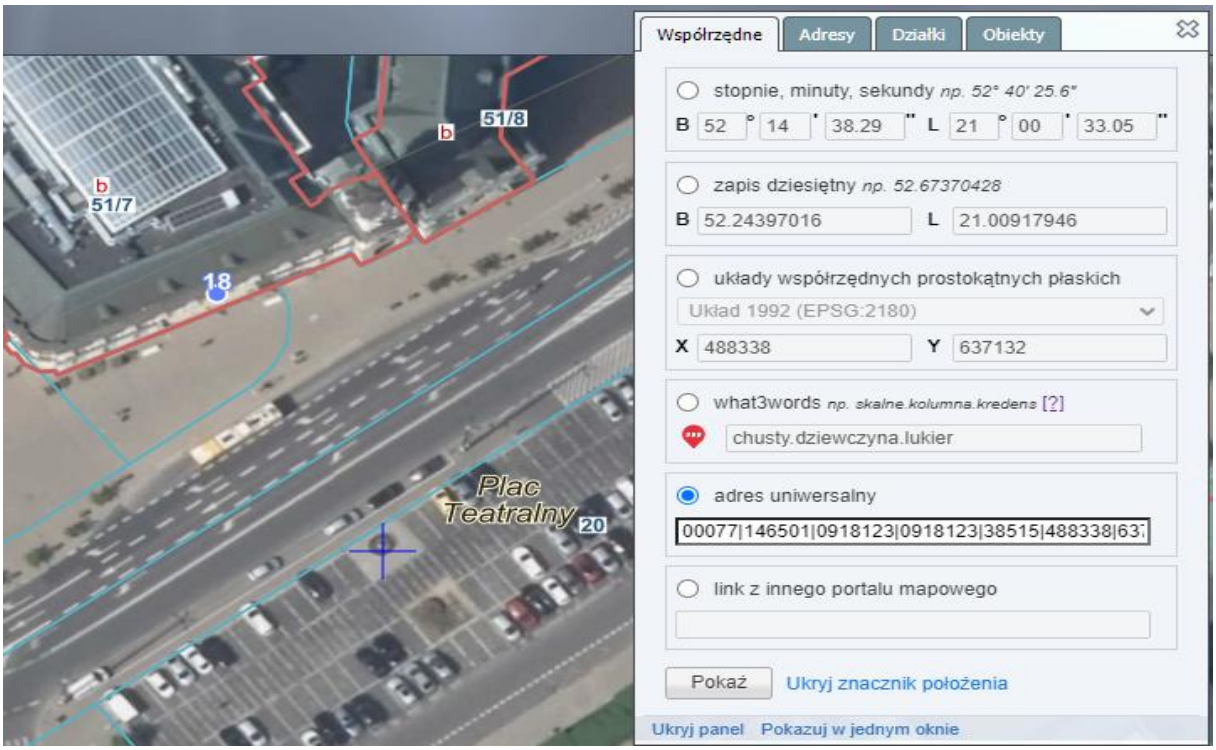

Figure 2. Converting a universal address to a human–readable address
Source: https://polska.e-mapa.net

The description of the structure and meaning of the elements of the universal address is provided on the website https://ezdrowie.gov.pl/portal/home/badania-i-dane/adres-uniwersalny.

More about the mentioned object can be found in Wikipedia at: https://pl.wikipedia.org/wiki/Południk_Warszawski.

The location of the facility can be easily visualized using the address verifier in Poland (https://polska.e-mapa.net).

The existence of an address in Poland in individual cases can be checked by using a dedicated application. It is enough to type in the data defining the address (city, street, number):

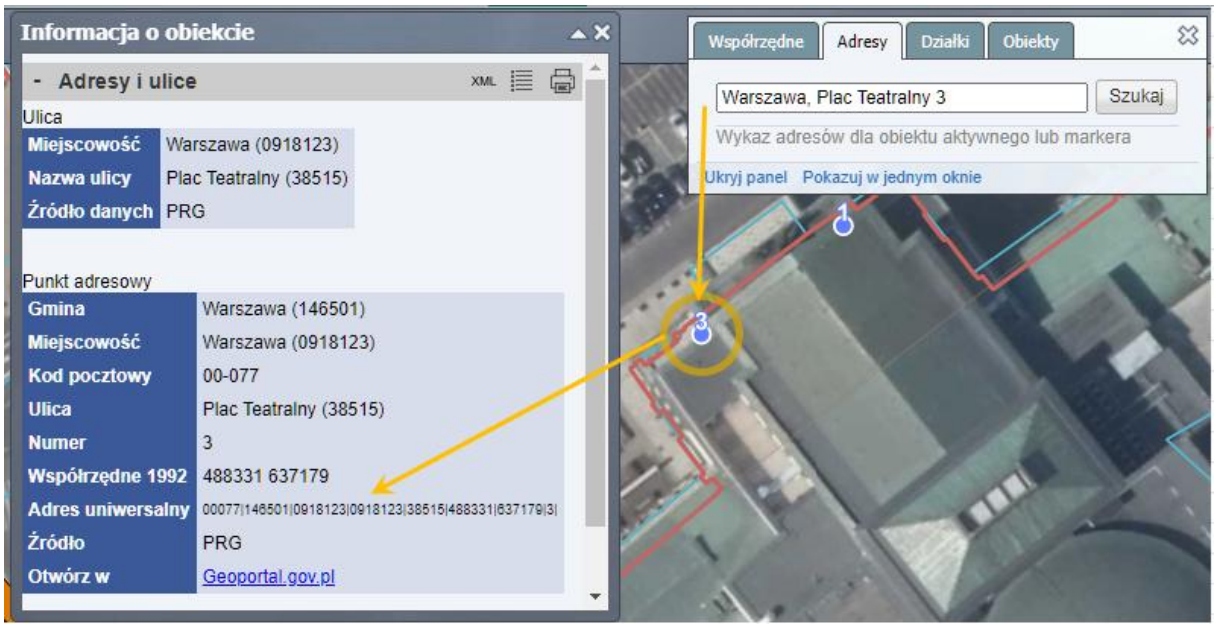

Figure 3. Verification of the existence of an address in the field
Source: https://polska.e-mapa.net

The practical importance of a universal address results from its role as a link between territorial codes and x, y geodetic coordinates, which are a kind of invariant of a place in the field. It should be noted that a change of address consisting in, for example, changing the name of a street will change the territorial codes assigned to specific geodetic coordinates x, y, but will not change the coordinates of this address point, defined in accordance with § 6 of the Regulation of the Minister of Development, Labor and Technology of July 21, 2021 on the register of towns, streets and addresses (Journal of Laws of 2021, item 1368).

The address https://itia.pl/adres ceased to be available after December 9, 2022. The authors are currently making efforts to launch similar functionality on other websites to enable anyone to check the existence of a specific address and determine its correct – lawful – record.

Below is an example of changing the street name from “ul. Dąbrowszczaków" into "ul. Prezydenta Lecha Kaczyńskiego” in Gdańsk. It is visible that apart from changing the

name and the code that is the identifier of this name, as well as the date of change, nothing has changed in this particular case – the ID is a combination of the city identifier and the street identifier – 12 digits define a specific street (alley, square, park, etc.) in a specific town. If there was a change in the territorial division of the country, which has already happened in the past, TerID would also change. If the street became an avenue, the feature would change and this would also change the street name identifier, however the x, y coordinates would not change. Thanks to the dates entered in the register of changes kept by the Central Statistical Office (GUS), it is always possible to determine the name of the object at different times (from December 31, 2006, from which the register is kept).

Table 2. List of some data included in the universal address

Data name	Before change	After change
ID	093301603694	093301642474
TerID	226101	226101
IdentyfikatorMiejscowosciPodstawowej	0933016	0933016
IdentyfikatorMiejscowosci	0933016	0933016
NazwaMiejscowosciPrzed	Gdańsk	Gdańsk
IdentyfikatorNazwyUlicy	03694	42474
Cecha	ul.	ul.
Wsp_x_PUWG_1992	728105	728105
Wsp_y_PUWG_1992	473798	473798
NazwaUlicyWPelnymBrzmieniu	ul. Dąbrowszczaków	ul. Prezydenta Lecha Kaczyńskiego
Stan	2017–12–22	2017–12–31

Source: own elaboration

The use of the character "|" (ASCII code 124) and x, y coordinates without decimal places in the universal address structure requires explanation. "|" character serves to protect against decomposition of the universal address during import/export to csv files, in which a comma, semicolon or tab is usually used as a separator, and rounding of coordinates to units from a practical point of view is sufficient, as it determines the location of a given address point with an accuracy of 1 meter. In addition, a strictly defined place of each territorial code in the universal address allows for easy localization of a given code and building the universal address structure in a format suitable not only for automatic decoding into a human-readable record, but also for a format suitable for automatic control of formal correctness.

In both confronted registers, the number of records changes almost every working day. As a result of removing obsolete street names, adding new names, and changing them from existing ones to new ones, the number of discrepancies also changes. This process is very dynamic. Below, for example, the number of various types of data discrepancies in 2021, 2022 and part of the current year, as at the end of the year and on the last day before submitting this article, is shown.

Tab. 3. Number of selected types of discrepancies

Year	A	B	C	D	Remarks
2021	131	3505	15698	259108	Whole year
2022	227	3395	15119	264504	Whole year
2023	114	3141	13972	266726	until May 20, 2023

Source: own elaboration

In the header of the table above, the individual letters mean:

A – The name of the street appearing in the PRG register is outdated (does not exist in any town).

B – The average of the number of unique identifiers, which are a combination of a city identifier and a street code in PRG that do not correspond to the name of the street entered in this register (code not related to the name of the street). This type of error most often occurs when the employee responsible for entering the street name into the register does not use the TERYT dictionary implemented in the geodetic system, but enters the name incorrectly manually or enters the wrong code.

C – The average of the number of unique records in which there is a literal discrepancy between the wording of the street name entered in the PRG and the wording of the street name in the TERYT register.

D – The number of unique identifiers that are a combination of the city identifier and the street code in PRG.

III. Croatian Register of Spatial Units – a potentially comparative case? In March 2023 an attempt was made to check whether a similar solution (application for verifying the correctness of addresses) exists in the Republic of Croatia, and if not, whether it could be created. The basic conditions for the creation of such an application are the openness of data and their non-requested availability, i.e. making them available in a way that allows for automatic comparison of dictionary data.

The State Geodetic Administration of the Republic of Croatia stated in March 2023 that it was responsible for the Register of Spatial Units in which data about spatial units were registered and maintained. All of registered spatial units have identification numbers and are linked to other spatial units in hierarchy. For example settlement “Murvica” with identification number 042510 is part of a municipality “Bol” with identification number 00272 and settlement “Murvica” with identification number 042528 is part of a municipality “Poličnik” with identification number 03450.

The State Geodetic Administration of the Republic of Croatia stated also that it currently does not provide a universal address structure similar to the one described in this article but it could be possible to build a similar structure because the Register of Spacial Units has all the necessary data:

country_code|county_code|city_or_municipality_code|settlement_code|street_code|E_coordinate_HTRS96/TM|N_coordinate_HTRS96/TM|house_number|

Regarding the payment for data, the State Geodetic Administration of the Republic of Croatia stated that it was planning to issue data free of charge soon, and that it should be contacted again in June 2023, as all necessary data is in the possession of the State Geodetic Administration of the Republic of Croatia, but not everything is yet possible to be fully opened and shared. Therefore, it will be possible to return to this topic only after obtaining information about the opening of resources containing appropriate codes and geodetic coordinates.

Conclusions

As it results from practical experience to date, the idea of using a universal address as a binding element in a strictly defined structure of object codes made available by entities appointed for this purpose can be an effective tool in data quality management, which for automatic processing is essential, and sometimes even crucial, especially when the safety of people depends on the quality of data.

The concept of universal address assumes that dictionary data from the TERYT register, i.e. name codes and names corresponding to these codes, are confronted with data from another register, but containing, among others, the same data, but in a different structure, also as codes with corresponding names recorded in this second register. Any difference in values in the corresponding pairs of both registers must be treated as a discrepancy requiring explanation. Thus, a similar concept – confronting (always in pairs, 1:1) theoretically the same data, but in different silos can be used for different data, not only addresses, but also for names of various products, names of entities, natural persons (when changing the name does not change ID of a natural person – e.g. Polish PESEL), comparing library statuses – however, there must always be some constant element constituting a reference. In the case of a universal address, these are the X, Y geodetic coordinates of a specific address point at a given time, in the case of an entity in Poland – REGON number, in the case of a natural person in Poland – PESEL number. The selection of registers for automatic comparison in order to detect discrepancies depends solely on the existence in these registers of data enabling the compilation of an unambiguous relationship and data constituting their counterparts.

The main reason for the occurrence of data discrepancies is the lack of mechanisms for updating data in time based on the source of creating these data and the lack of a mechanism for generating information about the occurrence of discrepancies. The authors of this article believe that all administrators of databases and registers under their management should analyze the occurrence of data in separate sets – and in the case of their repetition, create conditions for ensuring compliance (the same value of data at the same time in compared, different collections), and when it is not technically possible, provide an automatic non-compliance reporting system.

The previous experience (weekly downloading of data from PRG, TERYT and the register of changes in TERYT) allows us to conclude that any discrepancies in street names or building numbers can be found "manually" without much effort. Due to the proven effectiveness of the used universal address structure, it is postulated to create and introduce into practice automatic data verification on a daily basis through a system that downloads the appropriate central registers at night and collides data corresponding to the same geodetic coordinates. If discrepancies are detected, competent officials should take action to explain the reason for the discrepancy and correct the incorrect data on the next working day.

Since the "universal address" as a method of ensuring data consistency and good quality is possible to be used in Poland, one can try to apply it also in Croatia, which – as shown by the initial interaction with the competent institution – uses similar mechanisms (codes), and in other countries. Authors of this article will contact the State Geodetic Administration of the Republic of Croatia in June 2023 to follow up on the issue of opening the data collected in the Register of Spatial Units.

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