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A ROBUST UNIFIED MODEL FOR NATIONAL STREET GAZETTEER BASED ON LAND REGISTER AND GIS FOR THE REPUBLIC OF KOSOVO

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ABSTRACT:
A street gazetteer is a database of street names, addresses, and other relevant information that is used by various organizations, such as local governments, emergency services, and transportation agencies. A unified model for a national street gazetteer would standardize the way that this information is collected, stored, and shared across different regions or jurisdictions. This work includes a formal review process of data specification to ensure that the data model is correct and enhanced by current best practice for a unified address system. In developing countries like Kosovo, the lack of a complete and accurate base map to enable geocoding prohibits subsequent analysis of many geographic data sources for GIS (Geographic Information System) applications. One way to create a unified model for a national street gazetteer would be to base it on land, which means using geographic information to organize and categorize the streets and other features in the geodatabase. This could include using geographical coordinates, such as latitude and longitude, to pinpoint the location of each street, as well as other relevant data such as the type of terrain, land use, and environmental features.

Key-words: *Unified Gazateer model, GIS, Kosovo, Land register, Technical Geography*

1. INTRODUCTION

In many developing countries, there is a lack of a unified address catalog system to mark the location of a postal address which massively disrupts capacity building for emergency services, economic, and broad social development. There has been progress made in ongoing European initiatives, such as Infrastructure for Spatial Information in Europe (INPIRE) and existing standards for addresses (e.g. United Kingdom (UK), United States (US)), these approaches can be assessed to identify the best practices in address management. This research presents a real-world case study that existing data models are currently woefully inadequate and require major redevelopment to broadly mirror pan-European implementations for many post-communist address systematic approaches. The process of refining the data models as part of an objective data specification review to ensure client requirements are met while incorporating best practice enhancements where feasible. The process will benefit from the experience of other addressing implementations and pave the way for future interoperability between Kosovo, the European Union, and other European states.

The process of developing an address system, involves compiling accurate and complete base maps that can assign key attributes to important geographic features, such as street names, house numbers, and other land parcel attributes to ensure easy identification of people and places (Farvacque-Vitkovic & McAuslan, 2005, Davis Jr. et al., 2005, Coetzee & Cooper, 2007, Zandbergen, 2008, Yildirim et al., 2017). An effective street addressing system greatly increases the possibility of identification of a location of a parcel or dwelling in an urban area which can be utilized to facilitate service delivery, revenue generation, and emergency response services.

The aim of the study is to identify the best practices for the development of an address management system and analyze issues associated with the process and understanding the technological methods utilized for address system modernization.

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2. THEORETICAL BACKGROUND

2.1. INSPIRE Directive recommendation on addresses

The INSPIRE Directive is the foundational framework for address management and broader land cadastre modernization, providing an important understanding for building economic interconnectivity and development. According to the INSPIRE directives on addresses (Giff et al. 2008), the overall concept of this data specification is that an address has a "locator" that is represented as an address number that enables a user to distinguish it from the neighbor addresses; and a geographic position, which enables an application to locate the address spatially within the framework of explicit x- and y-coordinates. To identify the address unambiguously in a wider context, an address must be associated with several "address components" that define its location within a certain geographic area. Each of the address components represents a spatial identifier, such as the name of a road, district, postcode, municipality, region, or country.

The definition of spatial data themes and specifications for harmonizing the exchange of European spatial information has provided European states a roadmap for best practices in encoding postal addresses and implementing spatial data infrastructures. Despite widely different cadastral and administrative variances between EU member states, guidelines for defining address information have still been set out to benefit existing and proposed implementations.

The key standard features of the Address themes are (Giff et al. 2008):

- The implementation of spatially-enable Geographic Identifiers according to the ISO 19112 standard and the flexibility in the relationships between these identifiers in defining unique addresses for European states.
- The set of Geographic Identifiers associated with an address should distinguish a specific geographic location which unambiguously locates the address context.
- The identification of a unique locator which distinguishes itself from other addresses with similar Geographic Identifiers.

This locator is given a unique reference identifier, along with life-cycle attributes and temporal status to allow for dynamic information to be captured and incorporated. Alternative locators are also possible with different life-cycle, temporal or language frameworks. From the spatial point of view, the Address is one of many spatially referenced Geographic Identifiers which form a unique combination that definitively references a specific address. All address components are different, and many Geographic Identifiers are not prescribed or mandatory because all INSPIRE partners have the same systemic approach towards addressing requirements.

Within the Kosovo Address System, the constructs of INSPIRE Addresses should indicate the key Geographic Identifiers and how spatially enabled entities can be combined to assist in providing a framework to support geocoding unique identifiers for addresses. Providing equal importance within the system are the unique reference, life-cycle attributes, and temporal status information.

2.2. US Standards on addresses

US does not have a uniform standard of address for the whole country with the most extensive standard being developed by US Postal Service for the implementation of a mailing industry. Standardized address information enhances the processing and delivery of mail, reduces undeliverable mail, and provides mutual cost reduction opportunities through improved efficiency. The standards include uniform methods for matching addresses with the information in Address Information System (AIS) products and formats for outputting addresses on mail pieces. This standard describes how various elements appear on a mail piece or in an address record as well as the characters that constitute various address elements. The Postal Service defines a complete address as one that has all the address elements necessary to allow an exact match with the current Postal Service ZIP+4 and City State files, collated into a master address file by the Census Bureau, to obtain the finest level of ZIP+4 and delivery point codes for the delivery address.

2.3. UK Standards on addresses

The UK Land and Property Gazetteer (**Fig. 1**) specification found in the BS7666 standard is an extension of what is commonly defined as address register as it includes real-world objects called Basic Land and Property Units (BLPUs) where the INSPIRE addresses excludes them as Buildings, Cadastral Parcels, etc. However, the model has detailed specifications of addresses, streets as well as their identifiers which provide richer detail of how to create a unique and definitive address register. The uniqueness is specified in the constructs of Primary and Secondary Addressable Objects, as well as Street Identifiers with administrative attributes, with provision for alternative language entries existing alongside the primary address identifiers.

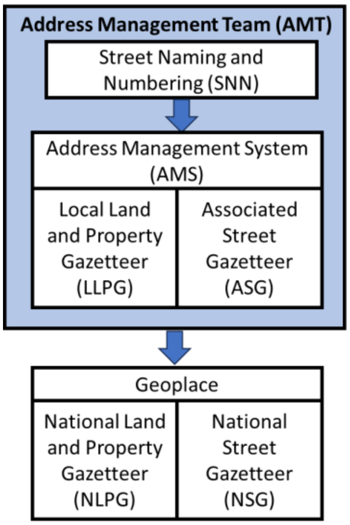

Fig. 1. The conceptual model of UK national street gazetteer.

While the INSPIRE Address theme specifies the importance of a spatially referenced ThoroughfareName (Defined as an address component which represents the name of a passage or way through from one location to another), the BS7666 standard for Addressing (current standard at BS7666:2006) further emphasizes the role of roads as a necessity for identifying unique addresses. According to the specification, the street or Unique Street Reference Number (USRN) is the spatial reference for any address identifier, referred as a Land and Property Identifier (LPI). While the underlying addressable object has a spatial attribute, this can often be different from a delivery or entry point or actual address identifier, which can always be classified as accessible via a thoroughfare access, which may be a street, footpath, waterway, etc. Real-world objects such as large buildings often have multiple entry points with different thoroughfare access points.

2.4. Non-English unification and modernization

2.4.1. Greenland

The country of Greenland, which exists as an autonomous country within the Kingdom of Denmark, had the fortune of leveraging Danish knowledge building and addressing system. Denmark struggled with creation of a unified address due to inconsistencies between business and building register information and with the governmental consolidation for authority (Coetzee et al., 2008). The model involves three separate databases: list of localities, technical base maps, and the NIN registry. The model struggles to maintain interconnect ability and making creation of a single point data address impossible (Siksnans et al., 2012).

2.4.2. Türkiye

Türkiye worked to update and unify its addressing standards in 2006, when it engaged local governments to study addressing. The discontinuity within the Turkish governments created a process where many local governments did not desire to update the system which greatly disrupted the national system unification process to build an Address Reference File (ARF). The system itself lacks continuity entirely and remains dysfunctional with a multitude of issues plaguing the implementation including no standard address format across municipalities, arbitrary changes to street names, no institutional connectivity for changes of address, no citizen participation, deficient legal frameworks for spatial information systems, no local government participation, and no creation of numerating maps. The geocoding process for this model resulted in an average location misplacement of 980m (Yomralioglu et al., 2014).

2.4.3. Poland

The most successful and well published modernization of stewardship methodological approaches was completed in Poland, which made a series of systematic updates with surveying, legal, and planning databases (Mika, Kotlarz and Jurkiewicz, 2020) . These developmental goals were subsided partially through the World Bank and occurred over a 30-year timespan. The implementation of the process was designed foundationally upon the INSPIRE Directive and aimed for Polish ascension into and connectivity with the European Union (Trystuła, Dudzińska and Źróbek, 2020). The Polish modernization experienced data deterioration problems which morphed sporadically at each stage of data consolidation (Zegar, Pęska-Siwik and Maciuk, 2023). Furthermore, the process of a more complete modernization involved broad scoped processes which posed incredibly labor-intensive solutions.

3. MATERIALS AND METHODS

The product of a formal data specification process should include the definition of the following elements:

a) Data domain definitions,
b) Relevant domain background information, and
c) The context of the data domain to the specified data objects.

This may include the relationship between the data model identified specifically, as well as it could help define the interactions required between the Graphical and Address component repositories. Full data object specification including data types, range values and data integrity, including mandatory/optional, conditional, and dependent values. In addition to the data model, this specification could be used by the web-based GIS Address Register application for form validation. Data entry conventions – data entry strategies provided in the context of practical issues and scenarios to ensure conformance and best practice within the data specification. These conventions could help streamline and automate actions behind the functionality provided by the web-based GIS Address Register application. Data transfer formats – a specification of how to exchange full datasets and possibly change information to provide supporting metadata and to ensure data integrity and verify completeness. All these activities provide greater detail of purpose and usage of the Address Register which will highlight where the data model needs to support data requirements and validate the integrity and conformance of the address information.

3.1. Implementation model

To build an address data model, there are many factors to be considered, including but not limited to specification refinement, temporal period, business processes, data structures, user interface(s) and infrastructure requirements. Building a National Street Gazetteer (NSG) includes layers of requirements to ensure that the product achieved is a long-term sustainable solution for the country. The proper way to design the best solution for the NSG of Kosovo will be to choose from several different options that should be investigated through a pros and cons analysis to improve model compatibility with current municipal functionalities.

NSG Implementation models	Pros	Cons
Use available existing data		
Use one of the existing addresses lists and data available on Open Street Map to be the starting point to which additional addresses, other attributes, coordinates, classifications and managed to create a template dataset.	•Simple implementation •Diverse data •Community-driven data management	•Difficulties with incorrect data •External data sources •Data privacy considerations •Licensing Requirements
Match and combine		
Match and combine the existing address lists to create a master list.	•Simple implementation •Comprehensive coverage •Increased accuracy through cross referenced data •Standardization of system	•Duplicate entries from illegal buildings •Collaboration required across organizations
Ignore and collect		
Ignore the existing lists and start the collection of addresses anew using the field work.	•New up-to-date data •Local context •Increase quality control •Requirement specific classification	•Time and resource intensive •Incomplete coverage due to illegal buildings •Human error •High maintenance cost and updates
Centralize and synchronize		
Centralize the organization and coordination of field work to build the initial list, though for the roll-out it could be that the field work is organized by each of the Municipal Offices (MO) to work with them which can be managed from with the institutional frameworks of bottom-up, top-down or hybrid approaches for best resource synchronization.	•Standardization •Resource Optimization •Data integration and stakeholder interoperability	•Loss of local context •Implementation challenges •Resource allocation difficulties •Local municipal buy-in

According to the Kosovo law in local governments (Official Gazette, 2008), the municipality has the responsibility for resolving street name and property number issues. This information can either be designed to input directly to the NSGK using a central maintenance facility or the local government can use a local hub for verification and then input into the master NSGK database. This can be achieved by the inclusion of several key aspects. The structure is effectively the skeleton of information with many opportunities to add additional entities if the need is identified. Examples are places of worship, public conveniences, sports facilities, ATMs, statues etc. The data structure should be designed to enable applications to collect a range of additional attribute data against the entities – for example this could be the age of the property, an organization name, floor area, rental history, energy performance (Black 2010).

The resultant NSGK could enable organizations in both governments, municipal and the public/private sector, such as the utilities, to check their own lists and ensure that they are complete and accurate. The process underpinning the NSGK ensures that the Municipality can keep the information up to date as changes take place. A facility must also be provided pertinent information so that others (users, citizens, companies) can provide feedback on environmental changes for which the Municipalities need to investigate, i.e. a large property split into flats. One of the key strengths to the proposed solution is the use of a Unique Reference Number (URN), which would be attached to every single address record to provide consistency (Black 2010). This URN can never be used twice (even after a property is destroyed), and so removes the occurrence of duplicate addresses.

Additionally, the URN approach can be used to link a set of external datasets in a different format, even if the recorded addresses vary to a degree. For example, an organization may wish to keep its own address list for a particular reason. By including the URN on address data in other systems, these numbers can be used as a comprehensive system of cross-referencing, giving confidence that all parties involved are using the same address. This framework allows for joined up working and the sharing of data with external organizations such as municipalities, public utilities and emergency services.

3.2. System Development

One of the most valuable solutions to develop a NSG should be the use of Java programming language with all source code made available through an Open-Source license. Using the OpenGeo suite with different data source architectures opens a large number of deployment possibilities. The use of Java is valuable not only because it is independent on OS but also reduce substantially the use of volume storage. Java source code does not compile directly into native machine code. Instead, Java compilation generates bytecode, which contains a high-level set of machine instructions that are general enough not to be platform-specific (Montelatici et al., 2005). The basic architectural pattern of using a database as a "single point of truth" allows a great deal of flexibility, both in supporting heterogeneous environments and evolving over time. The Software Architecture of NSG could be implemented as a multi-tier architecture with totally independent development and running software components. Multi-tier architecture has significant positive impacts and provides great advantages in factors such as costs, time, effort, and characteristics of Software Quality (complexity, usability, efficiency, reliability, integrity, adaptability, robustness, maintainability, portability, testability etc.) (Keβler et al., 2009). Open-source geospatial tools provide facilities such as cost effectiveness and it can be customized according to user needs. Also, various spatial queries can be made to assist decision making. They are helpful in monitoring various rural development schemes run by the government (Kumar, 2008).

3.3. Data Store

According to current developments in the Database (DB) technology, one of the data store solutions could be a single datastore based on Open-Source Solution PostgreSQL including Spatial Extensions PostGIS to ensure address-based data consistency at the database level. PostgreSQL is an open-source descendant of this original Berkeley code. It supports a large part of the Structured Query Language (SQL) standard and offers many modern features: complex queries, foreign keys, triggers, views, transactional integrity, multiversion concurrency control, PostGIS “spatially enables” the PostgreSQL Server (Fig. 2), allowing it to be used as backend spatial database for geographic information system (GIS), much like ESRI’s SDE or Oracle’s Spatial extension. At the database level, this database can be made available in ‘Graphical Component’ form and ‘Address Registry’ form, through Linked Databases and Web Services. It is certified as compliant with the Open Geospatial Consortium (OGC) "Simple Features for SQL" specification. While databases offer the strongest combination of data integrity, integrated analysis, and support for write operations. A web service can discover and invoke any service anywhere on the Web, independently of the language, location, machine, or other implementation details. The goal of Semantic Web Services is the use of richer, more declarative descriptions of the elements of dynamic distributed computation including services, processes, message-based conversations, transactions, etc. (Shalini & Seema, 2010).

3.4. User Interface

For the user interface, it is recommended that a combined Graphical and Address Register user interface can be accessed via a web browser. This idea requires further development within the Kosovo government for implementation within the proper bureaucratic process for proper implementation. This can be built in a way that will allow the Address Register to plug into the Graphical element. This will also allow the Address Register to be available as an independent Text based system if required. In **figure 2**, it is represented that the system architecture of a Web-GIS based systems when using Java and PostGIS geodatabases.

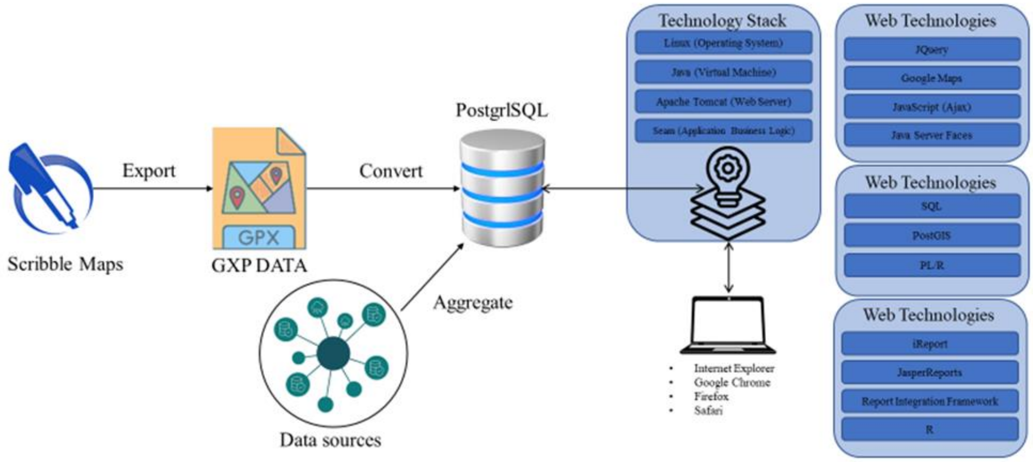

Fig 2. Open GIS System architecture.

It is highly recommended to use integration libraries with jQuery to ensure that a fully feature rich mapping interface is provided. OpenLayers makes it easy to embed a dynamic map in any web page. There are multiple objectives of map interface, with the primary of providing digitization capacity which streamlines the processes required for conversion of physical addresses into digital. Secondary objectives such as integration, interoperability, and collaboration provide strong social incentives which allow for broad development capacity. The map interface includes validation mechanisms to ensure data accuracy and integrity. It may include validation rules for address formats, consistency checks, and error detection. This creates the capacity to maintain data quality and reliability within the master address file. Incorporation of security measures designed to protect the master address file and control access to sensitive address information is imperative for mapping interface. User authentication, role-based access controls, and data encryption are implemented to safeguard data privacy and prevent unauthorized access. Functionalities for updating and maintaining the master address file are paramount for design functionality. Allowing enabled users to add new addresses, modify existing ones, and mark addresses as inactive or removed. This ensures that the address file remains up-to-date and reflects any changes or additions accurately. These processes provide for a modernized reliable map capable of safeguarding privacy for a robust unified national street gazetteer.

4. DISCUSSION

An NSG for Kosovo will involve considerable difficulties from multiple internal and external issues. Türkiye serves as an analog for governmental issues that could arise within the application, given the geopolitical likeness. Kosovo has weak government institutions and institutional corruption will dominate the process in formation of a unified model implementation. The “municipalization” of Kosovo and the creation of autonomous Serbian enclaves inside of Kosovo will create further issues towards a systemized and unified address system. Modern technology and approaches can be utilized to mitigate aspects of systemic failures for implementation. The formulation of a ground-up strategic approach that will allow for top-down sorting of troubled municipalities can be leveraged to ease these issues. Maintaining the model at a national level will be extremely difficult given the weakness of governmental connectivity will provide considerable barriers towards data upkeep across Kosovo.

The geopolitical issues that come from the hostage-state position pose significant issues through lack of ethnic municipality cooperation. The political situation creates a necessity for adaptability in approach which gives power for strategic management approaches that engage key stakeholders while providing opportunities for different approach avenues on difficult government institutions. The need for dual language requirements increases the difficulty as both Albanian and Serbian datasets will require consistent synchronization. An open-source model provides the most reasonable method for the project but is overshowed by regional political pressures that could cause the model to become weaponized for political gain. The political issues associated with gazetteer modernization is not well described in the literature.

A major issue that will be faced in the creation and modernization of the land and building gazetteer will be the extremely high occurrences of illegal and unregistered buildings. The strategies to overcome this can be a low-tech human survey-based solution or a high-tech deep learning approach. The utilization of data intensive deep learning algorithmic approaches to increase building location accuracy provides a baseline application for correction of the illegal and unregistered buildings which currently plagues Kosovo (Zhuo et al, 2018 & Ma et al., 2019). Major hurdles remain within the application of these methods, the capacity for multi-sensor fusion building detection has shown successes (Zhang et al., 2019 & Lai et al, 2019). The implementation advanced technological solutions towards modernization have displayed levels of success for country-wide applications for cadastre modernization in Poland (Wierzbicki, Matuk and Bielecka, 2021).

A gazetteer is a linear progression towards a more completed land and building cadaster (LBC). The LBC develops further to include ownership with increased accuracy towards geolocation through is a linear progression of the modernization process (Kocur-Bera and Stachelek, 2019 & Kocur-Bera 2019 & Wierzbicki, Matuk and Bielecka, 2021 & Mika, 2020). Importantly the Polish modernization process benefited significantly from a well-organized multi-stage approach towards data collection, consolidation, and management. The modernization using existing data models requires an in-depth formal review process of data specification to include technical documentation of address data domain, data objects, and attributes. The unification process must fall within well-defined data entry conventions and data transfer protocols to facilitate information exchanges that will occur between various data formats. Each stage of data consolidation and unification of formats yields compounding errors within the resulting addressing system, these issues are multiplied as project complexity increases in complete land cadastre modernizations.

Data scarcity on road networks is a considerable roadblock towards rapid street gazetteer modernization which was solved in Ghana using service data of a service known as Trotro to provide more representative road networks (Dumedah and Eshun, 2020). Utilization of the approach of multi-agent-based addressing provides an architectural framework that shows high potential for modernization applications (Kebe, Faye and Lishou, 2021). There is considerable capacity in Pristina for data consolidation and utilization. It is clear within the literature that capitals cities with higher economic development produce data capable of rapid approaches to modernization but extending that data into rural areas appears more challenging.

There is historical precedence towards land administration systems tendency for reflecting their jurisdictions of origins (Enemark, Williamson and Wallace, 2005). A likely implementation issue that will surface for Kosovo are those which occurred within the Turkish addressing system modernization, given in part to the shared Ottoman stewardship political mechanisms that decentralize governing power of political systems required for addressing unification and modernization. These issues will largely occur within the spheres of; failure to reduce incompatibility, errors for door numbers, and mismatched addresses (Yomralioglu et al., 2014).

5. CONCLUSIONS

The modernization of an addressing system requires a high degree of planning, coordination, and cooperation from involved stakeholders. These are required to improve data quality assurance and quality control capabilities. Data issues become compounded with each progressive step towards unification of an addressing system and political dysfunction increases data dysfunction. The INSPIRE Directive is fundamental foundation for best practice modernization and open-GIS tools offers cost effective technological alternatives. The technologically advanced approaches which exist to attempt rapid modernization tend to work in isolated geographies and are difficult to scale for country wide modernization. Open GIS frameworks cover much of the technological gaps required for an effective low-cost addressing system unification, though there is a need for adequate funding and community buy-in as seen in Poland for higher degrees of success. The NSG implementation model for Kosovo will require a high degree of adaptability with significant time investment into planning to ensure best outcomes. The largest barriers for model implementation will emerge from within political institutional corruption and regional instability, as their impacts on land registry modernization is not well defined within the research.

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