Semantic Visual Query Answering on Heterogeneous Territorial Data

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Presenters

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Project

This work reports some of the outcomes of the Geo@Reporter project, developed as a collaboration with GeoPartner (Trento, Italy)
https://www.geopartner.it/servizi/georeporter/
https://dkm.fbk.eu/projects/georeporter

Objectives and contributions

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- **Contributions:**
  1. semantic integration of real estate and associated tributes data
  2. support for semantic visual analytic, and query formulation and geo-visualization
- **Delivered assets:**
  1. **Ontology** for the domain or real estate and taxation
  2. Scripts for **ontology population** with data from cadastre, municipal registry, and household utilities
  3. System for the **visual query answering** over the integrated knowledge base

Ontology: Structure and Development

Ontology specification

Aim

To represent the key objects types of the domain, i.e., buildings, their cadastral subdivisions together with their owners and their associated features, the activated services, and the taxation relations.

Specification language

The ontology is specified in Web Ontology Language (OWL 2), which allows us to take advantage of the available tools for modelling and reasoning in the standard ontology language.

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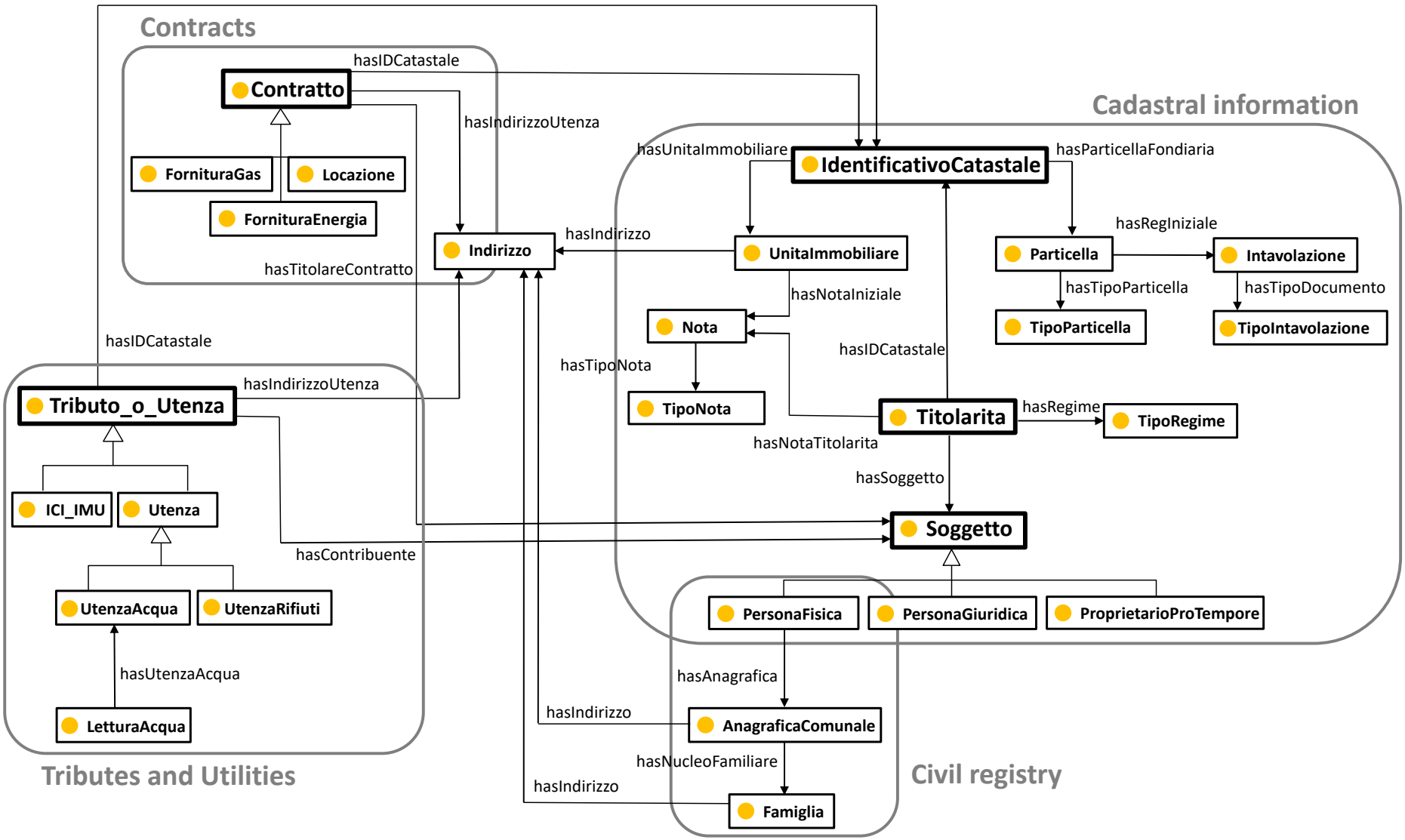
Information from the municipality about real estate tributes for the specific year. The main objects are municipalities taxes to be linked to local real estate units.

Utility and rent contracts:

Data about rents and utility contracts for waste collection, gas, electricity and water were provided by the municipality. The main objects of interest are contracts (and their related information) for the different utilities linked to specific real estate units.

General schema of the Geo@Reporter ontology



Ontology population with real data

Data sources

- Cadastral data: provided in a proprietary format in form of pipe-separated text files (together with documentation for interpretation of fields).
- Civil registry data: provided as comma-separated values (CSV) format files for individuals and families units.
- Real estate tributes: provided as a spreadsheet export of the administrative software of the municipality.
- Utility and rent contracts: extracted as spreadsheets from the Sistema Interscambio Anagrafe Tributarie Enti Locali (SIATEL) system for exchange of tributary data in the Italian public administration.

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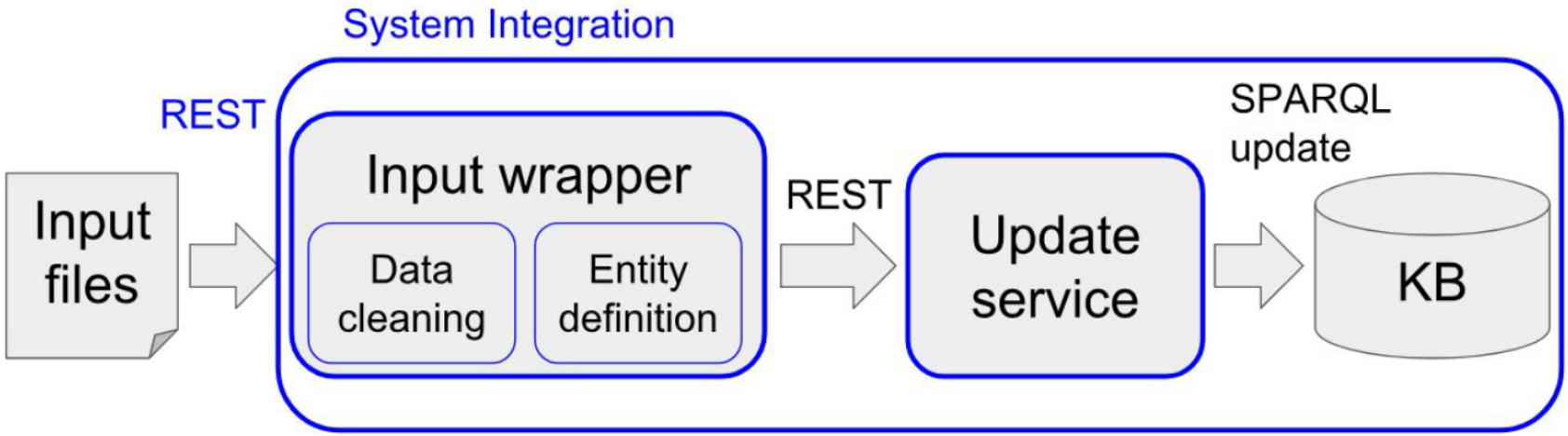
Note

Sources are heterogeneous for format and structure of the data, while also overlapping on some of the represented objects.

Ontology population system



Import process

1. Input wrapper component works on the format of the input files to apply data cleaning operations and to recognize relations across entities.
2. Update services, implemented as *Representational State Transfer (REST)* interfaces, allow to interact with the KB in order to add to the KB (or update) the information derived from input files in terms of the structure of the ontology.

Visual Query Answering System

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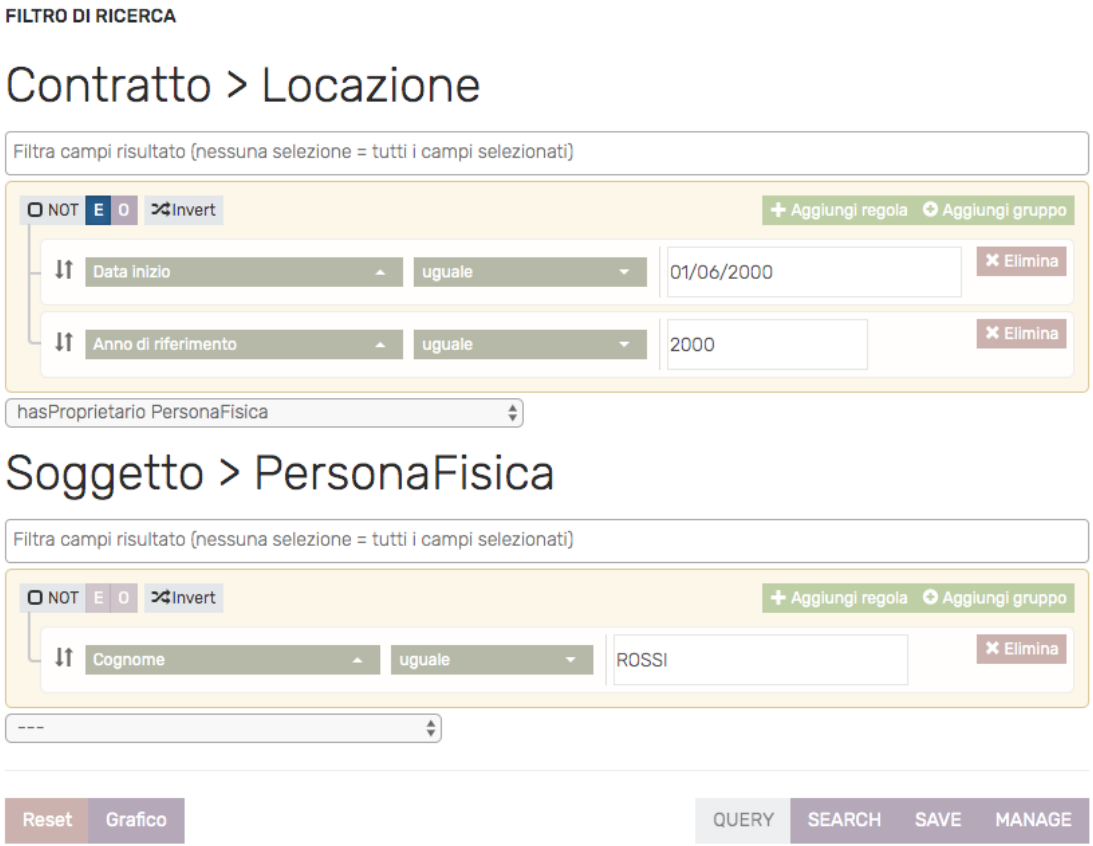
Components

- Smart Query Builder: a visual-based system for complex ontology based query building
- Logic Tree: a visual representation of the query results, highlighting the relationship between the items
- Hybrid 2D/3D Geographic Information System (GIS): a multi-level visualization that combines 2D and 3D environments to inspect geo-referenced entities

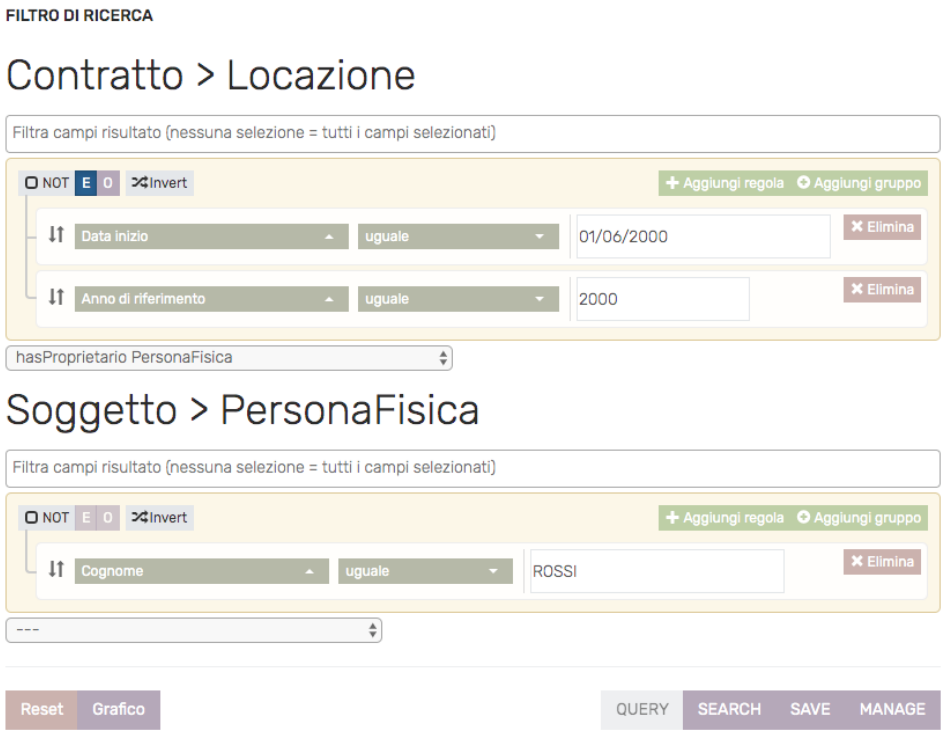
Smart Query Builder

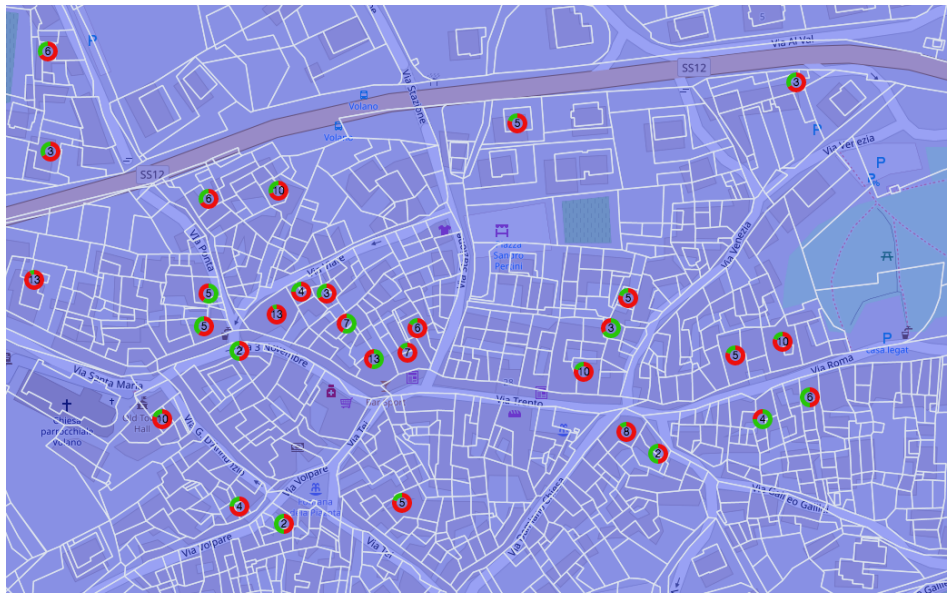


After choosing the first entity (i.e., *Contratto Locazione*, rent contract), the list of connected entities is available in a drop-down menu. The user can choose mathematical and logical operators in a dedicated drop-down menu and insert free text in the empty box to complete the query with custom parameters. As long as the Smart Query Builder finds relations with other entities, the user can keep adding new boxes, creating a more complex query.

Smart Query Builder

Example of graphical and geo-referenced representation of the results of the query:

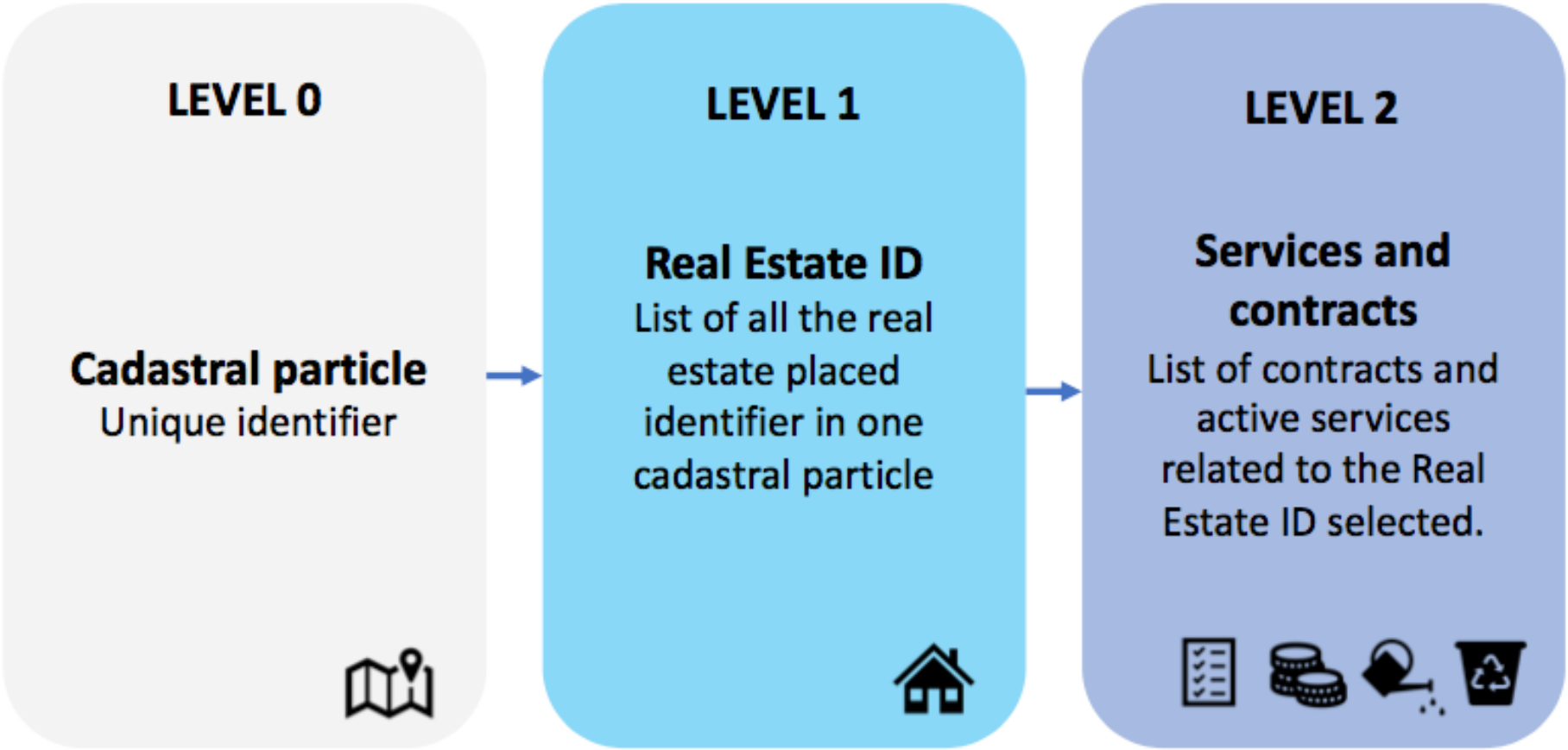




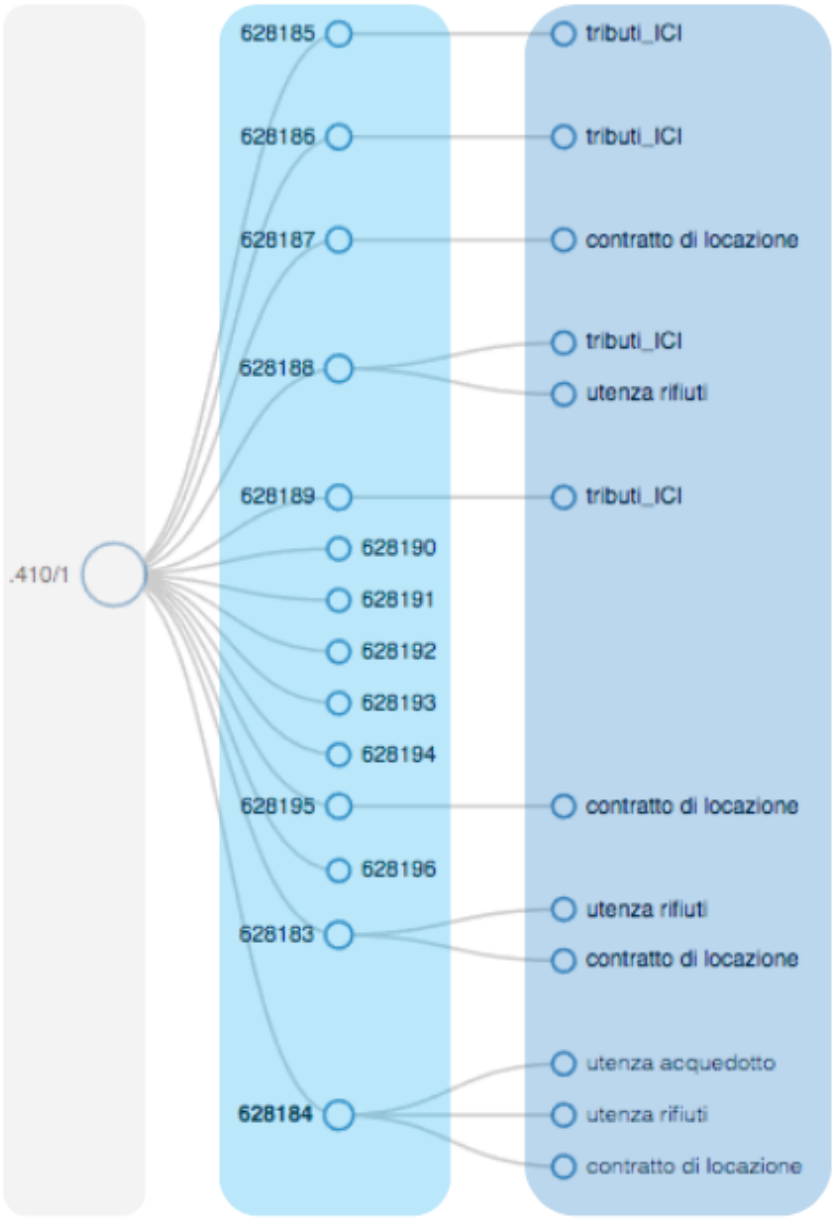
(Map data © OpenStreetMap contributors, CC BY-SA)

Logic Tree

In order to highlight the association between cadastral parcel, real estate identifier (*Unità Immobiliare*) and personal/services/tax-related data in the ontology, we defined a graphical logic structure to represent the relations between the various entities.



Logic Tree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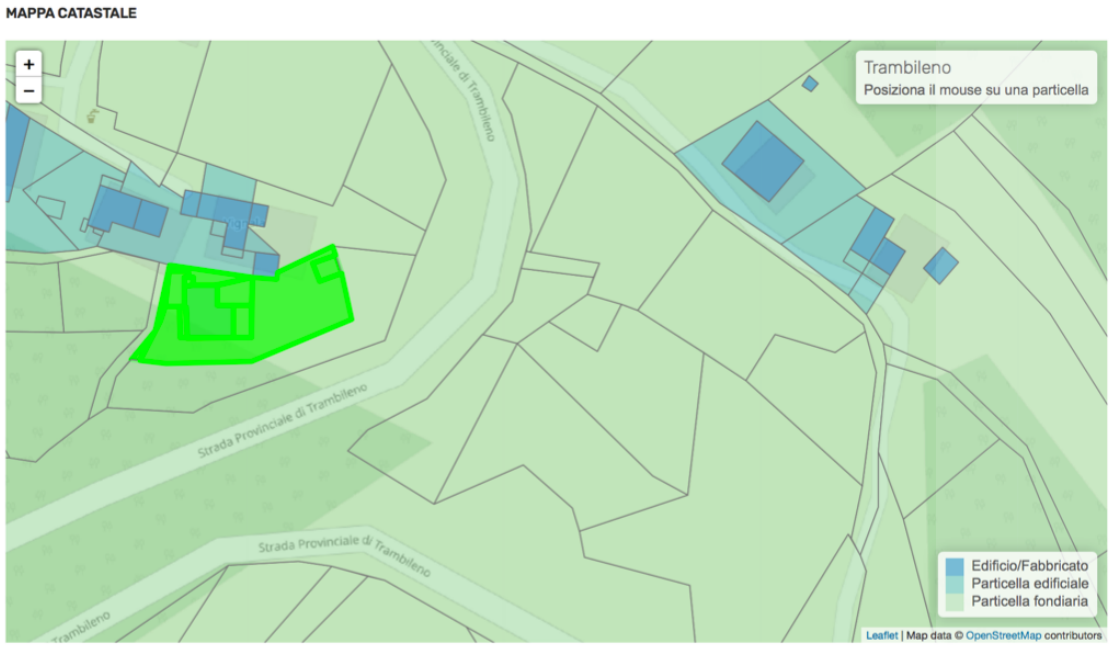
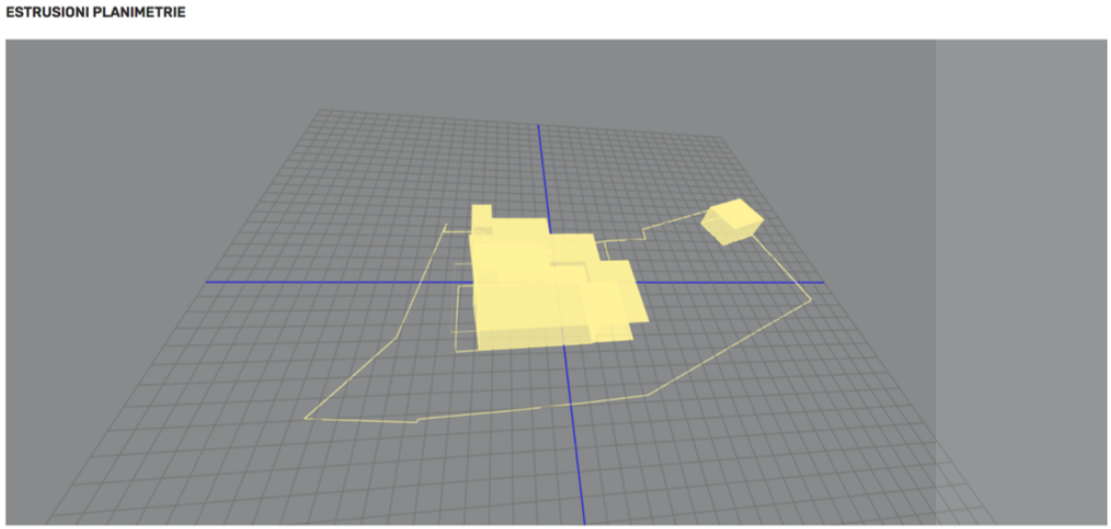
Hybrid 2D/3D GIS System

After a usability test (performed with the domain experts) we choose a hybrid representation to explore provided by a tool called Three.js where the point of view of the visualization is always fixed towards the center of the building and the library allows the reconstruction of those parts that are under the road surface, allowing a complete exploration of the structure.





Conclusion

Contributions of our work can be summerized in three points:

1. We first detailed the structure and modelling of the project ontology, by showing how the different data sources guided the schema definition.
2. Then, we detailed the integration system of the platform, which allows to clean and map different data formats to the semantic based representation of the project KB.
3. Finally, we presented our solutions for data visualization, providing different tools for data analysis and 2D/3D map navigation.