UNIVERSITÀ DEGLI STUDI FIRENZE

DINFO
DIPARTIMENTO DI INGEGNERIA DELL'INFORMAZIONE

DISIT
DISTRIBUTED SYSTEMS AND INTERNET TECHNOLOGIES LAB

Km4City Ontology, Tools, Data Ingestion, and Applications

Km4City Ontology, Protégé, WLODE, Virtuoso,
Open Street Map, Osmosis, PostgreSQL+PostGIS, Sparqlify,
Real-Time Traffic Estimation of Unmonitored Roads

We are going to…

- Introduce some useful tools
- Draw an outline of the Km4City Ontology in its entirety
- See the Street Guide section of the Km4City Ontology in great detail
- Inspect the correspondences between the resources in the Km4City KB that represent the street graph, and the Open Street Map
- Discover how information about the Km4City Ontology can be found in the source XML/RDF document, in Protégé, and in the Km4City KB

- Outline the process for the ingestion of the Open Street Map data
- Introduce a notable application based on the street graph stored in the Km4City KB: the *Real-Time Traffic Estimation of Unmonitored Roads*
- Present the *Datameter*, a DISIT Lab research (and set of tools) for measuring relevant features and performing an automatic characterization of triplestores

Tools

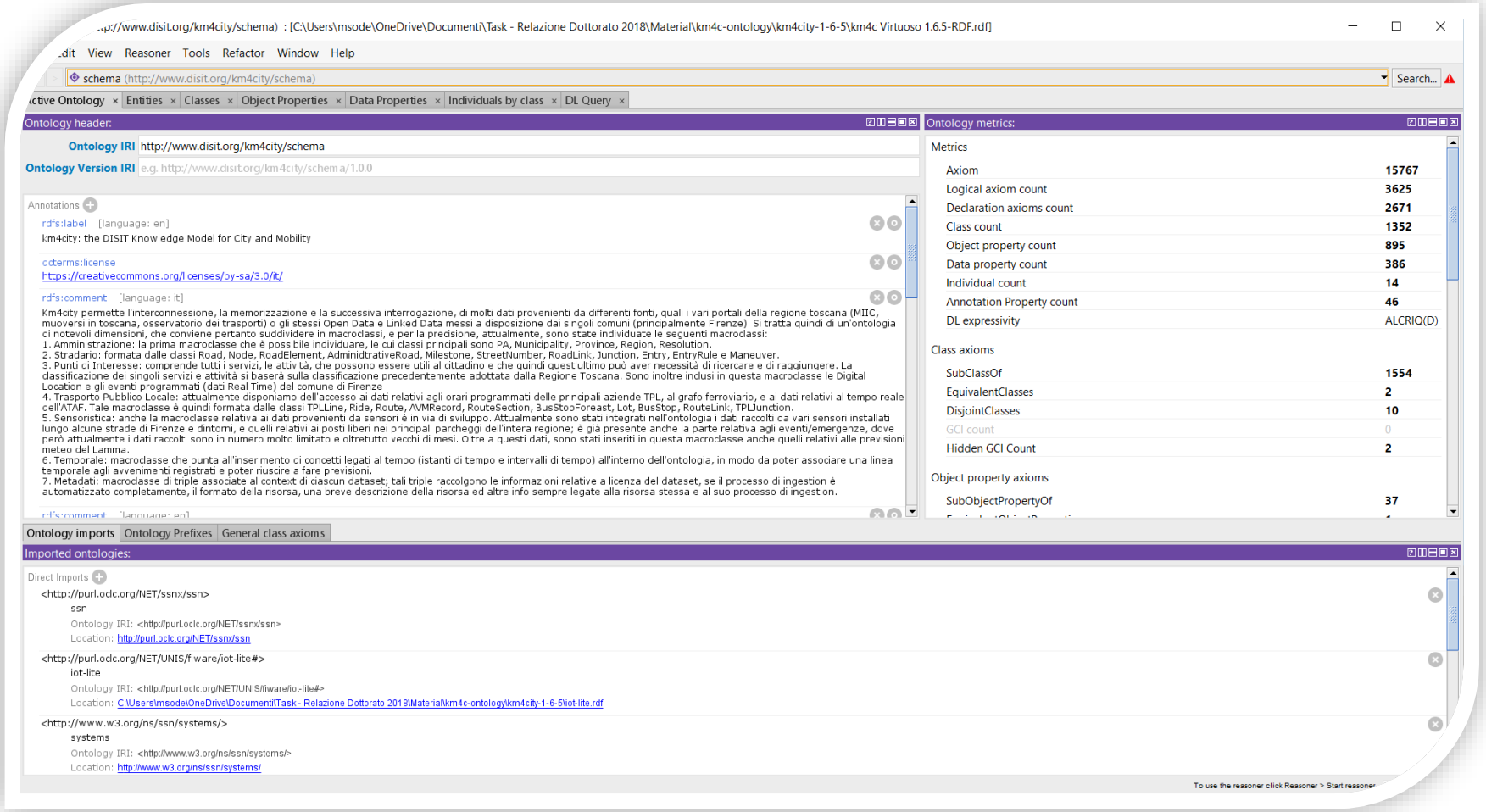
- Protégé ***v5.2.0+***
  - "A free, open-source ontology editor and framework for building intelligent systems" (https://protege.stanford.edu/)
- WLODE
  - "Automated OWL ontology documentation generator with graphics and diagrams, Web Linked Open Data engine and graphics" (https://github.com/disit/WLODE)
- Linked Open Graph
  - "A visual tool for browsing on Linked Data and Linked Open Data" (https://github.com/disit/linked-open-graph)
- Virtuoso
  - "Conceptually, Virtuoso provides a *Data Junction Box* that drives enterprise and individual agility by deriving a Semantic Web of Linked Data from existing data silos." (https://virtuoso.openlinksw.com/)
- Open Street Map
  - "OpenStreetMap is a map of the world, created by people like you and free to use under an open license." (https://www.openstreetmap.org/)
- …

Protégé

- "A free, open-source ontology editor and framework for building intelligent systems" (https://protege.stanford.edu/)

- The Km4City Ontology is developed with Protégé.
- Download the ZIP file at **http://www.disit.org/**drupal/?q=home&axoid=urn%3Aaxmedis%3A00000%3Aobj%3Aa863cca5-6dcc-492d-9afa-0c852aa34ae2
- Open the extracted RDF file with Protégé, and.. Enjoy! ☺

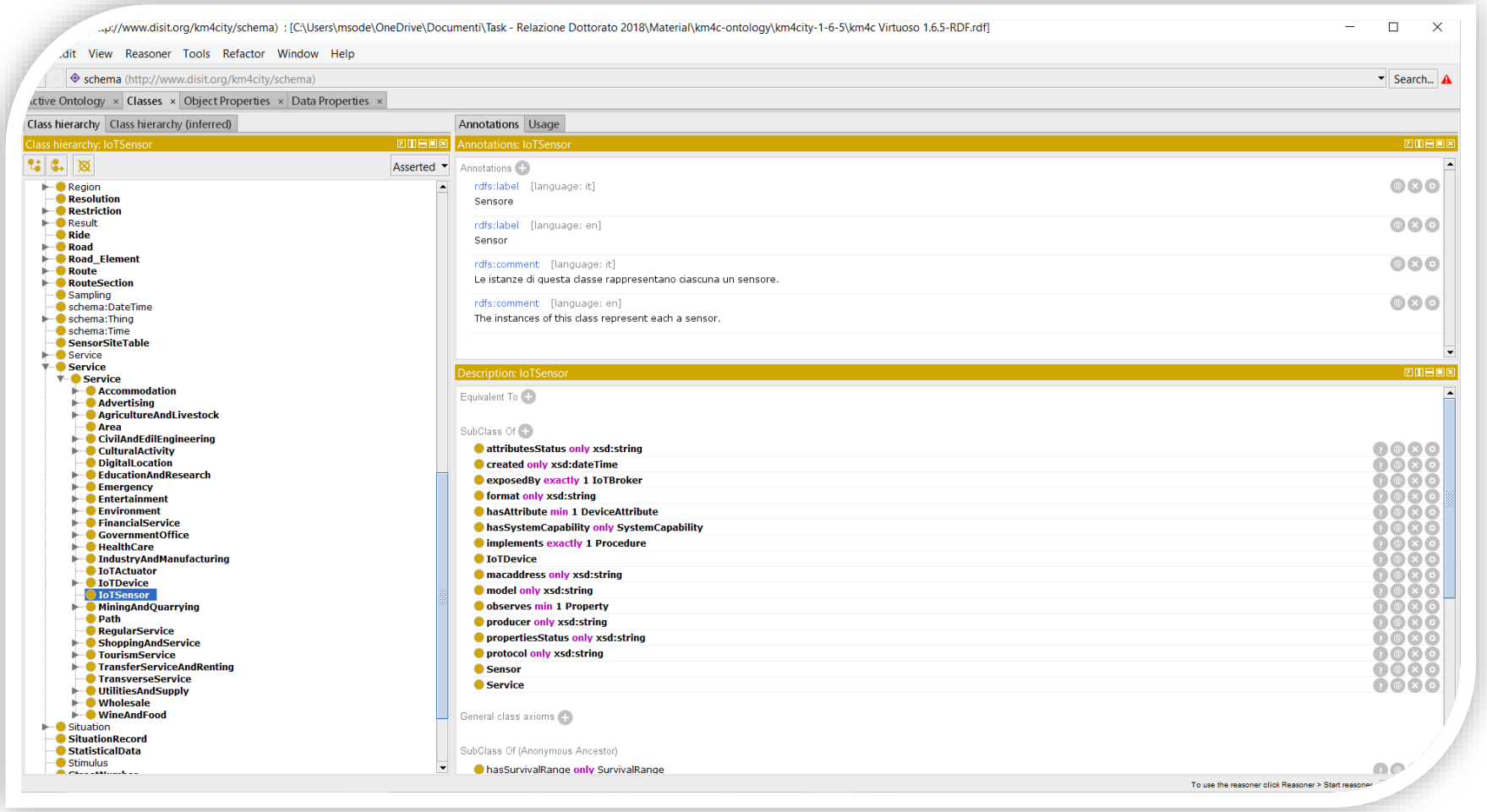
Protégé: Active Ontology



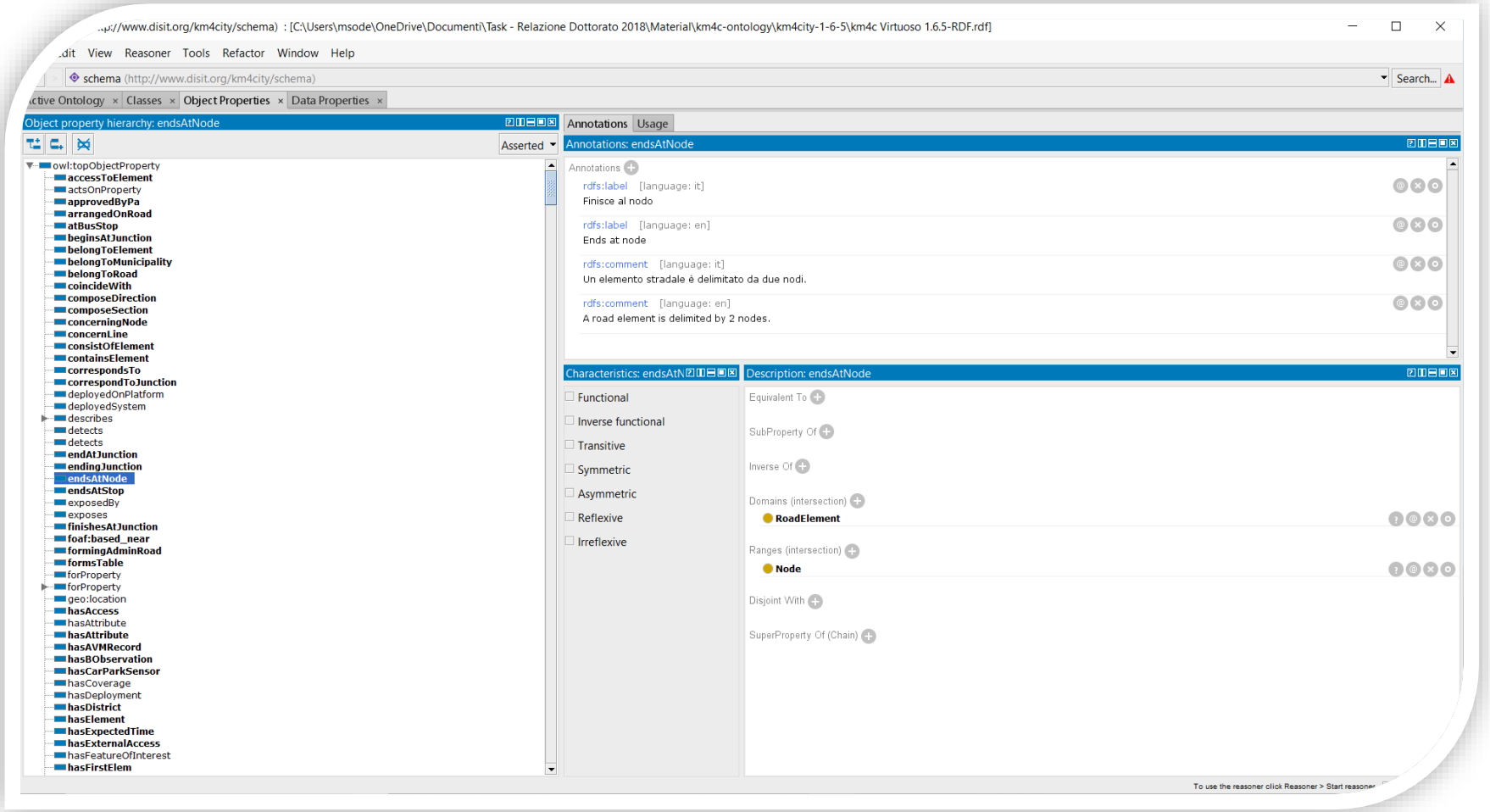
XML/RDF: Ontology Metadata

```
<Ontology rdf:about="http://www.disit.org/km4city/schema">
    <rdfs:label xml:lang="en">km4city: the DISIT Knowledge Model for City and Mobility</rdfs:label>
    <dct:description xml:lang="en">A Knowledge Model to describe a smart city, that interconnect data from infomobility service, Open Data and other source</dct:description>
    <dct:publisher>DISIT Lab, University of Florence, Italy, http://www.km4city.org</dct:publisher>
    <dct:creator xml:lang="en">DISIT lab: info@disit.org, km4city@disit.org </dct:creator>
    <dct:contributor xml:lang="en">Nadia Rauch, Municipality of Florence, Tuscany Region</dct:contributor>
    <vann:preferredNamespacePrefix>km4c</vann:preferredNamespacePrefix>
    <dct:subject xml:lang="en">Ontology, Semantic SEO, RDFa, Linked Data, RDF, Semantic Web, Smart Recommender Systems, Smart City, Transportation Network, Smart Mobility, Citizens Services, Semantic Model, knowledge model
    </dct:subject>
    <dct:creator xml:lang="en">Pierfrancesco Bellini, Paolo Nesi, Mirco Soderi</dct:creator>
    <dct:rights xml:lang="en">The Knowledge Model for the City - km4city - is available under Creative Commons Attribution-ShareAlike 3.0 Unported license</dct:rights>
    <vann:preferredNamespaceUri>http://www.disit.org/km4city/schema</vann:preferredNamespaceUri>
    <rdfs:comment xml:lang="en">The km4city knowledge model enables the description of smart cities, leveraging interconnection, storage and interrogation of data from many different sources, such as various portals of the
    Tuscan region (MIIC, Muoversi in Toscana, Osservatorio dei Trasporti), Open Data and Linked Data, provided by individual municipalities (mainly Florence). It is therefore evident that the ontology will be built, will
    not be small, and so it may be helpful to view it as consisting of various macro classes, and to be precise, at present, the following macro-categories have been identified:
    1. Administration: the first macroclass that is possible to discover, whose main classes are PA, Municipality, Province, Region, Resolution;
    2. Street Guide: the main classes of this macroclass are Road, RoadElement, AdministrativeRoad, Milestone, StreetNumber, RoadLink, Junction, Entry, Node, EntryRule and Maneuver;
    3. Points of Interest: includes all services, activities, which may be useful to the citizen, and that may have the need to reach. The classification of individual services and activities will be based on
    classification previously adopted by the Tuscany Region. Digital location and scheduled events (real time data), from the municipality of Florence, are also included in this macroclass. In general, all the classes that
    specialize the class Service belong to this macroclass;
    4. Local Public Transport: currently we have access to data relating to scheduled times of the leading LPT, the graph rail, and real-time data relating to ATAF services. This macroclass is then formed by many classes
    like TPLLine, Ride, Route, AVMRecord, RouteSection, BusStopForeast, Lot, BusStop, RouteLink, TPLJunction.
    5. Sensors: the macroclass relative to data coming from sensors is developing. Currently in the ontology have been integrated data collected by various sensors installed along some roads of Florence and in that
    neighborhood, and those relating to free places in the major parks of the whole region; in our ontology is already present the part relating to events/emergencies, where, however, the collected data are currently very
    limited in number plus several months old. In addition to these data, in this macroclass were included also data related to Lamma&apos;s weather forecast. Some of the main classes forming this macroclass are
    SensorSite, SensorSiteTable, CarParkSensor, SituationRecord, Weather_sensor, Observation.
    6. Temporal: macroclass pointing to include concepts related to time (time instants and time intervals) in the ontology, so that you can associate a timeline to the recorded events and can be able to make predictions.
    7. Metadata: set of triples associated with the context of each dataset; such triples collect information related to the license of the dataset, to the ingestion process, if it is fully automated, to the size of the
    resource, a brief description of the resource and other info always linked to the resource itself and its ingestion process.</rdfs:comment>
    <versionInfo xml:lang="en">V 1.6.5 RDFSPlus Adaptation, Release 2018-02-19</versionInfo>
    <dct:title xml:lang="en">km4city, the DISIT Knowledge Model for City and Mobility</dct:title>
    <imports rdf:resource="http://purl.oclc.org/NET/UNIS/fiware/iot-lite#"/>
    <imports rdf:resource="http://purl.oclc.org/NET/ssnx/ssn"/>
    <imports rdf:resource="http://schema.rdfs.org/all"/>
    <foaf:homepage rdf:resource="http://www.disit.org/"/>
    <foaf:homepage rdf:resource="http://www.km4city.org/"/>
    <imports rdf:resource="http://www.w3.org/ns/ssn/"/>
    <imports rdf:resource="http://www.w3.org/ns/ssn/systems/"/>
    <dct:license rdf:resource="https://creativecommons.org/licenses/by-sa/3.0/it/"/>
</Ontology>
```

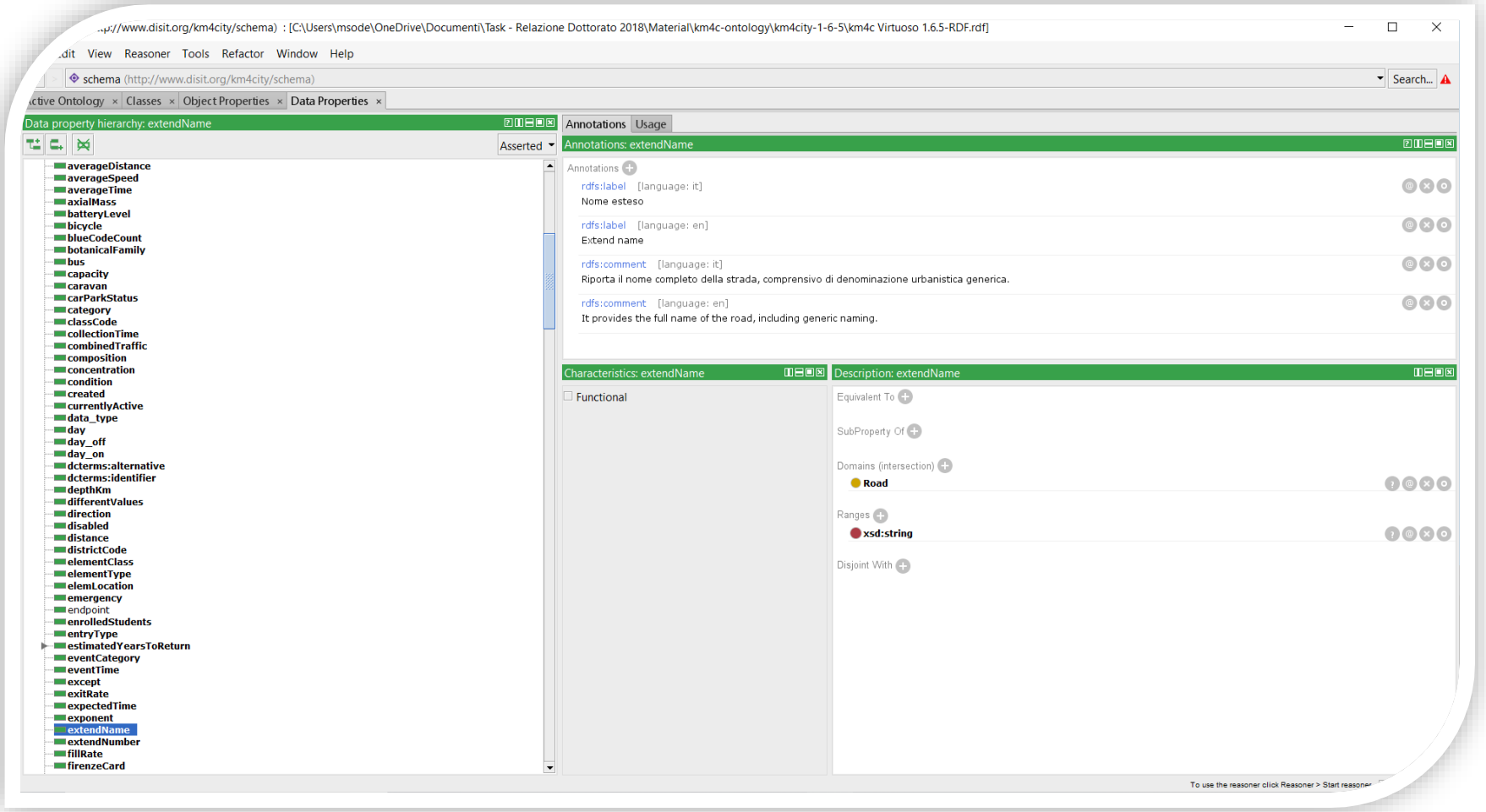
Protégé: Classes



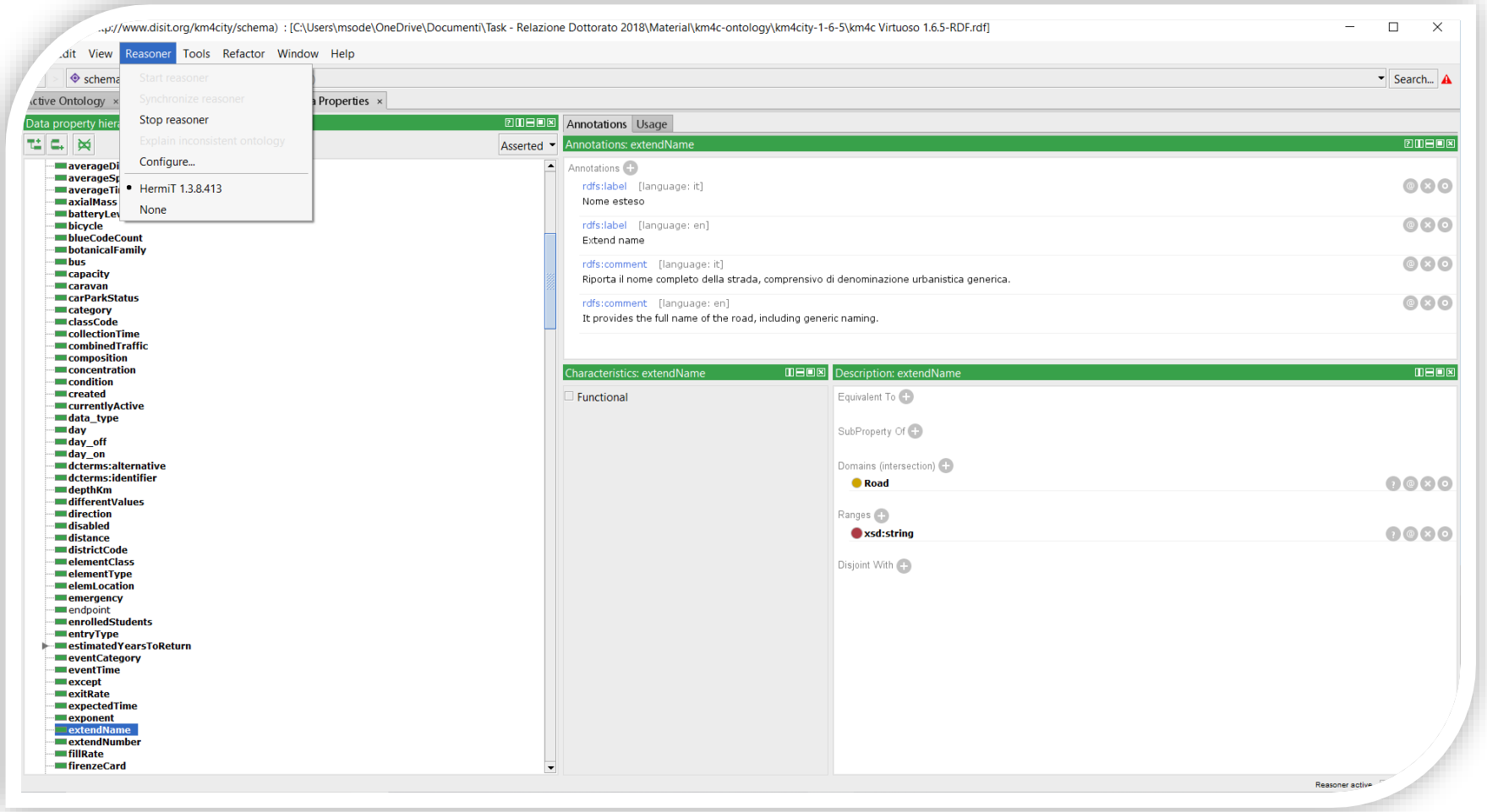
Protégé: Object Properties



Protégé: Data Properties



Protégé: Reasoning



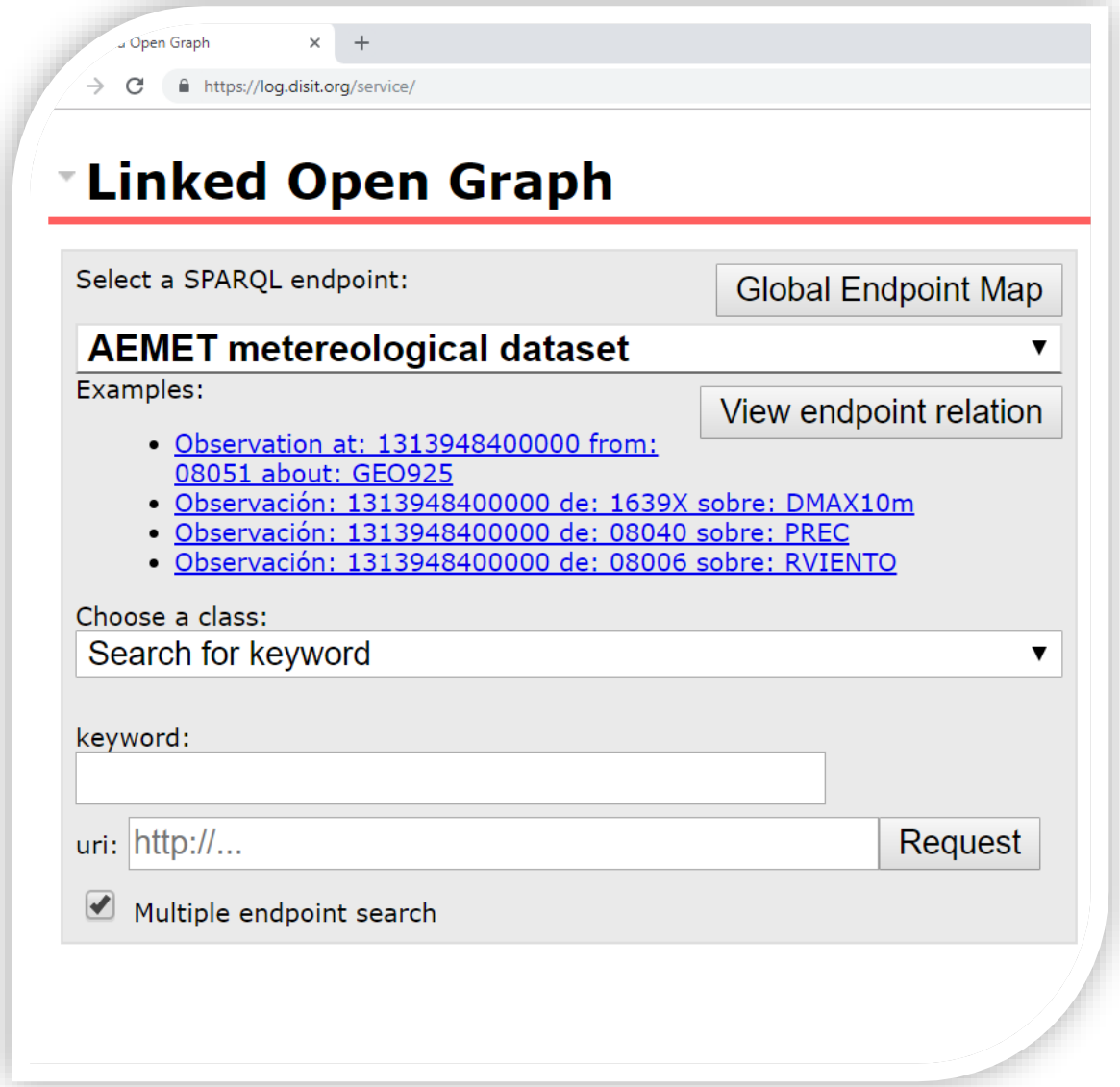
WLODE

- WLODE is an ***"Automated OWL ontology documentation generator with graphics and diagrams, Web Linked Open Data engine and graphics"***
- It *generates* (XML/SVG/PNG) diagrams of concepts and entire ontologies on-the-fly, based on the XML (RDF/OWL) representation of the ontology.
- It *generates* a complete Web (HTML) documentation of an ontology on the fly, including diagrams also generated on-the-fly, based on the XML (RDF/OWL) representation of the ontology.
- It is open source software developed by the DISIT Lab and it is available for download at https://github.com/disit/WLODE. Feel free to get it, and... Enjoy! ☺ A lot of work still has to be done.
- Diagrams that you can see in these slides, all are generated by WLODE.

Linked Open Graph

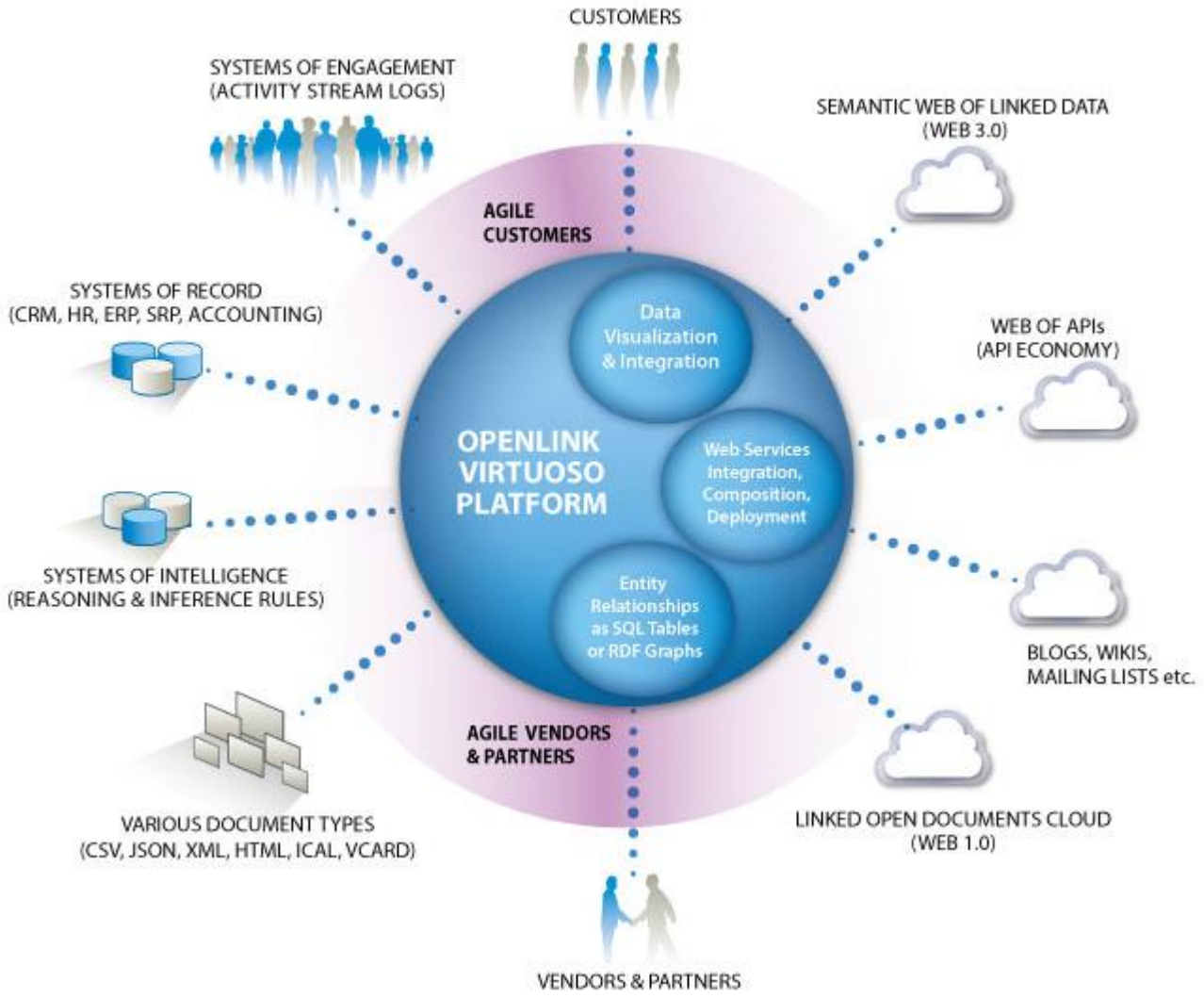
- Select a dataset, and browse resources within it in a visual manner.
- The Linked Open Graph (LOG) is a Web tool developed at DISIT Lab.
- It can be reached at:

  https://log.disit.org/



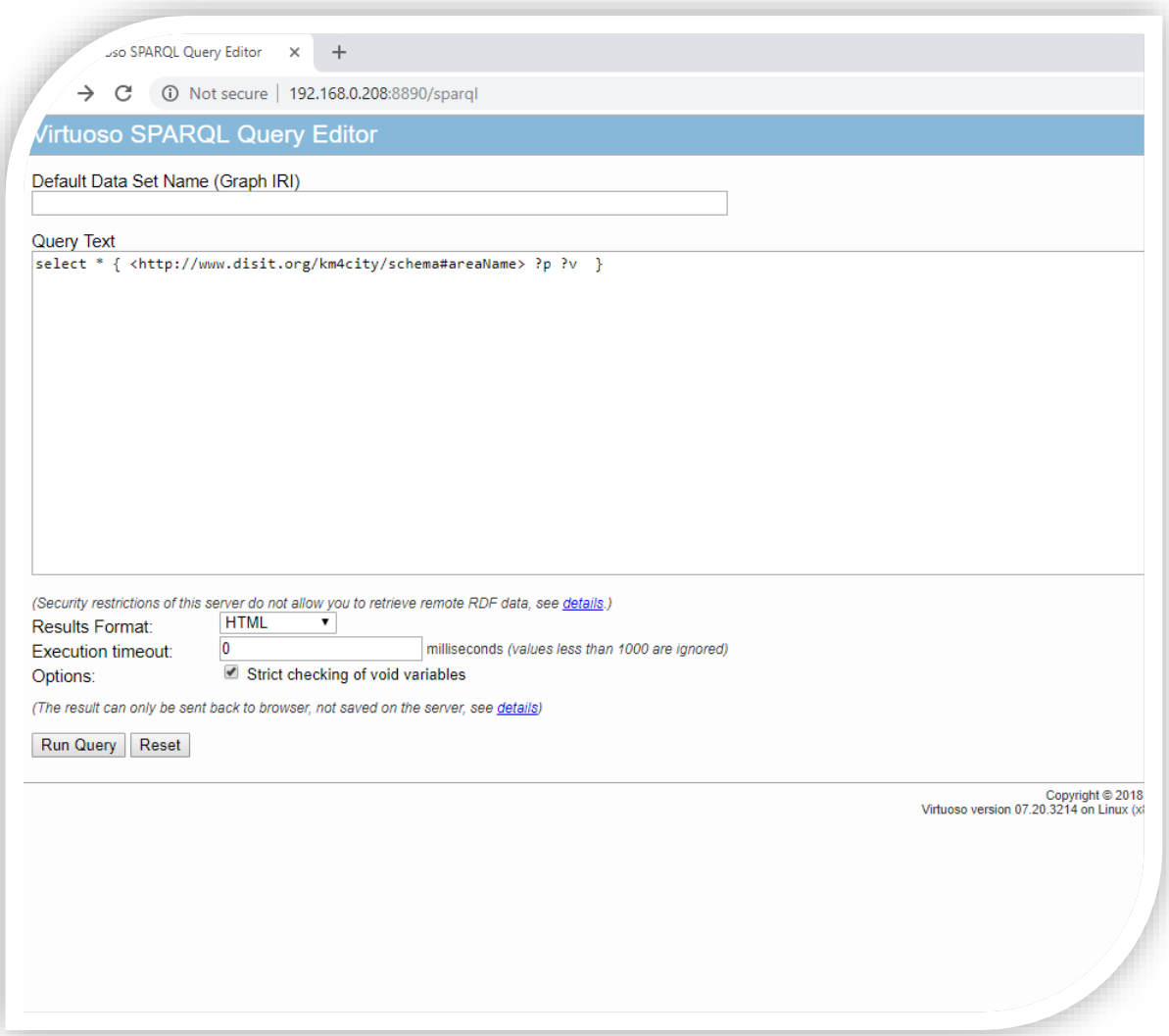
Virtuoso: Quick Introduction

- Virtuoso is a open-source software
- It is a No-SQL database (triplestore) management system, and much more
- It is the DISIT Lab choice for the Km4City Knowledge Base
- Get it and learn more at: https://virtuoso.openlinksw.com/
- It can be queried through a dedicated Web interface (the SPARQL query editor), through REST API calls, …



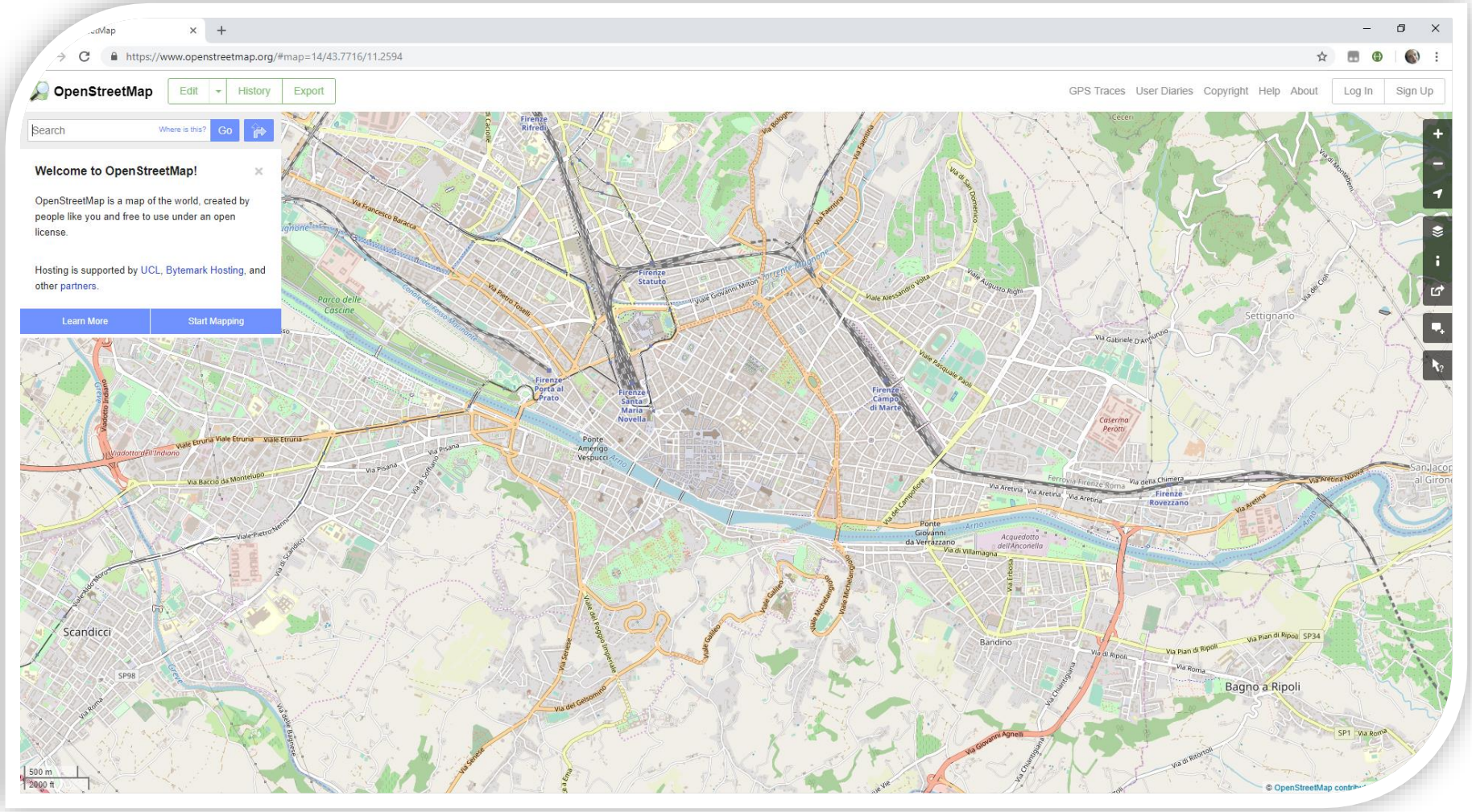
Virtuoso SPARQL Query Editor

- For each Virtuoso server instance a Web interface is available for submitting SPARQL queries
- Different result formats are available



Open Street Map

www.openstreetmap.org



Open Street Map: Ways, Nodes, Tags

- Ways
  - “A way is an ordered list of nodes which normally also has at least one tag or is included within a Relation. A way can have between 2 and 2,000 nodes, although it's possible that faulty ways with zero or a single node exist.” (https://wiki.openstreetmap.org/wiki/Way)
- Nodes
  - “A node is one of the core elements in the OpenStreetMap data model. It consists of a single point in space defined by its latitude, longitude and node id.” (https://wiki.openstreetmap.org/wiki/Node)
- Tags
  - “A tag consists of two items, a *key* and a *value*. Tags describe specific features of map elements (nodes, ways, or relations) or changesets. Both items are free format text fields, but often represent numeric or other structured items. Conventions are agreed on the meaning and use of tags, which are captured on this wiki.” (https://wiki.openstreetmap.org/wiki/Tags)

Open Street Map: Relations

Type	Status	Element	Comment	Photo
multipolygon	**de facto**		For areas where the outline consists of multiple ways, or that have holes; also used for boundaries.	
route	**approved**		Like bus routes, cycle routes and numbered highways	
route_master	**approved**		route_master contains (parallel, opposite, variant, …) routes only; heavily used to group route variants in public transport.	
superroute			Avoid, superroute contains (concatenable) routes only.	
restriction	**de facto**		Any kind of turn restriction.	
boundary	**de facto**		For grouping boundaries and marking enclaves/exclaves.	
site	**de facto**		Relation to group elements of a site such as a school together.	
associatedStreet			House numbers related to a street. See Karlsruhe scheme. Somewhat controversial.	
public_transport	**approved**		Part of the OSM public transport scheme. Mainly used by `public_transport=stop_area`.	
network	**de facto**		Relations that describe networks with their members being the members of this network.	
street			Bind all parts of a street together and everything else that belongs to it.	
destination_sign	**approved**		Destination signs at or before intersections.	
waterway	**approved**		Relation to group elements of a `waterway=*`.	
enforcement	**approved**		Traffic enforcement devices; speed cameras, redlight cameras, weight checks, …	
bridge	no vote		Groups together all elements of one bridge.	
tunnel	no vote		Groups together all elements of one tunnel.	

Ontologies: Quick Review

- Aimed at modelling (a part of) the World

- Made up of:
  - Classes (Concepts, Categories of objects/resources)
  - Relations among classes (generalizations, specializations)
  - Data Properties (Features of objects/resources)
  - Object Properties (Relations among objects/resources)
  - Constraints (Cardinalities, data types, …)
  - …

Ontologies: Quick Review

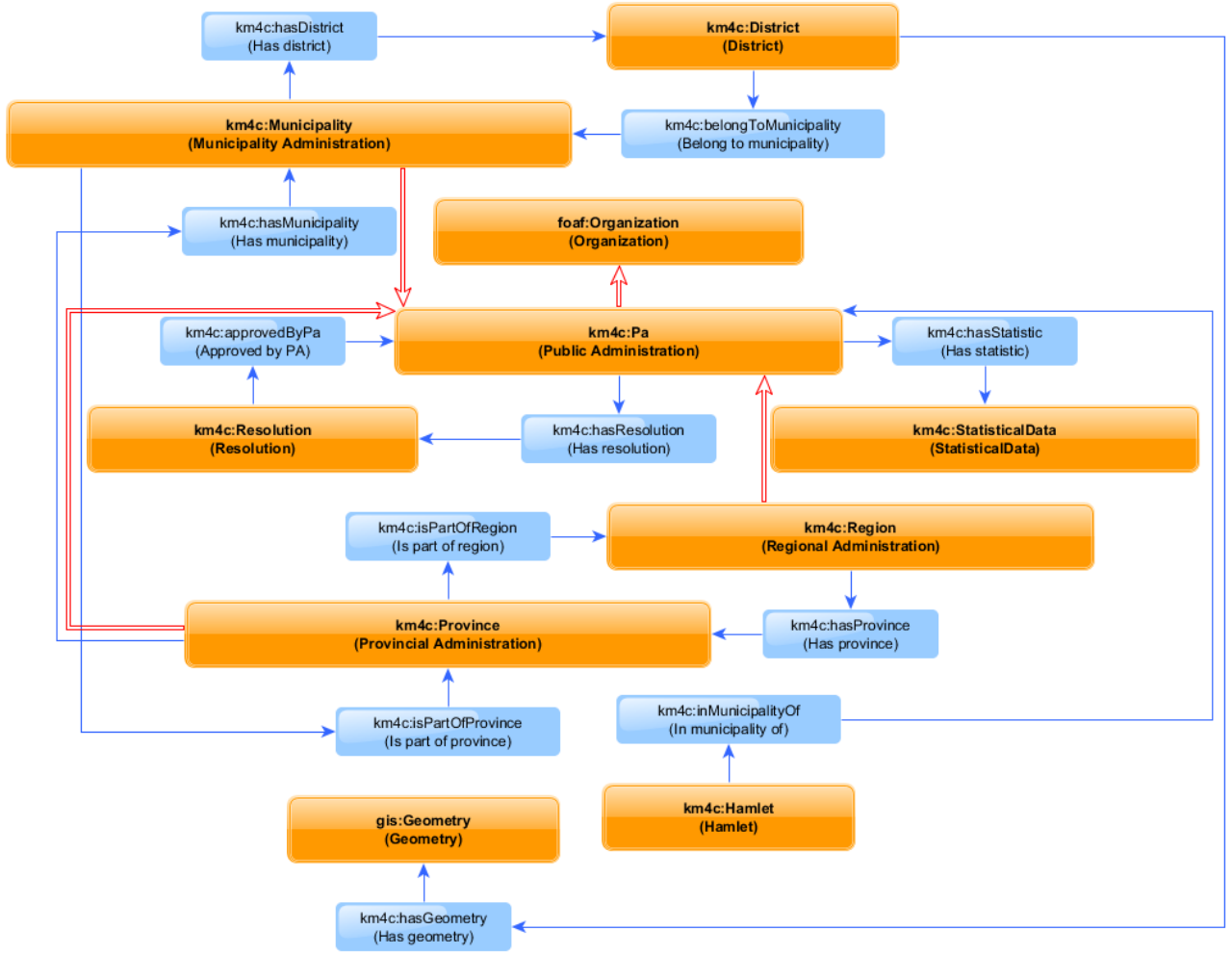
- Represented as XML documents
- Developed through dedicated tools (Protégé, …)
- (Possibly) loaded to triplestores and queried through SPARQL
- Documentation is a key aspect. Tools exist that attempt to produce human-readable documentation automatically (WLODE, …)

Km4City Ontology

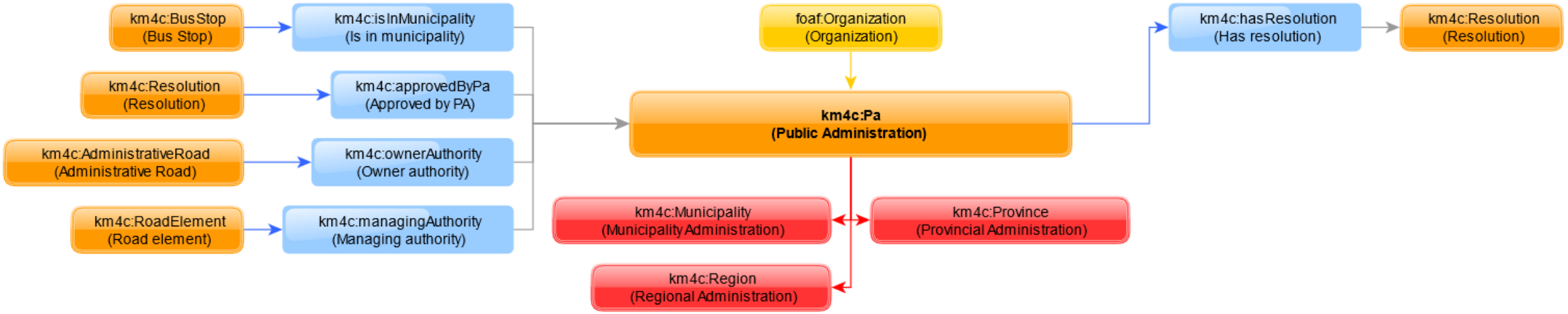
- Administration
- Street Guide
- Points of Interest
- Local Public Transport
- Sensors
- Temporal Aspects
- Metadata

Km4City Ontology: Public Administration

- Organization
- PA
- Region
- Province
- Municipality
- Hamlet / District
- Resolution
- StatisticalData
- Geometry

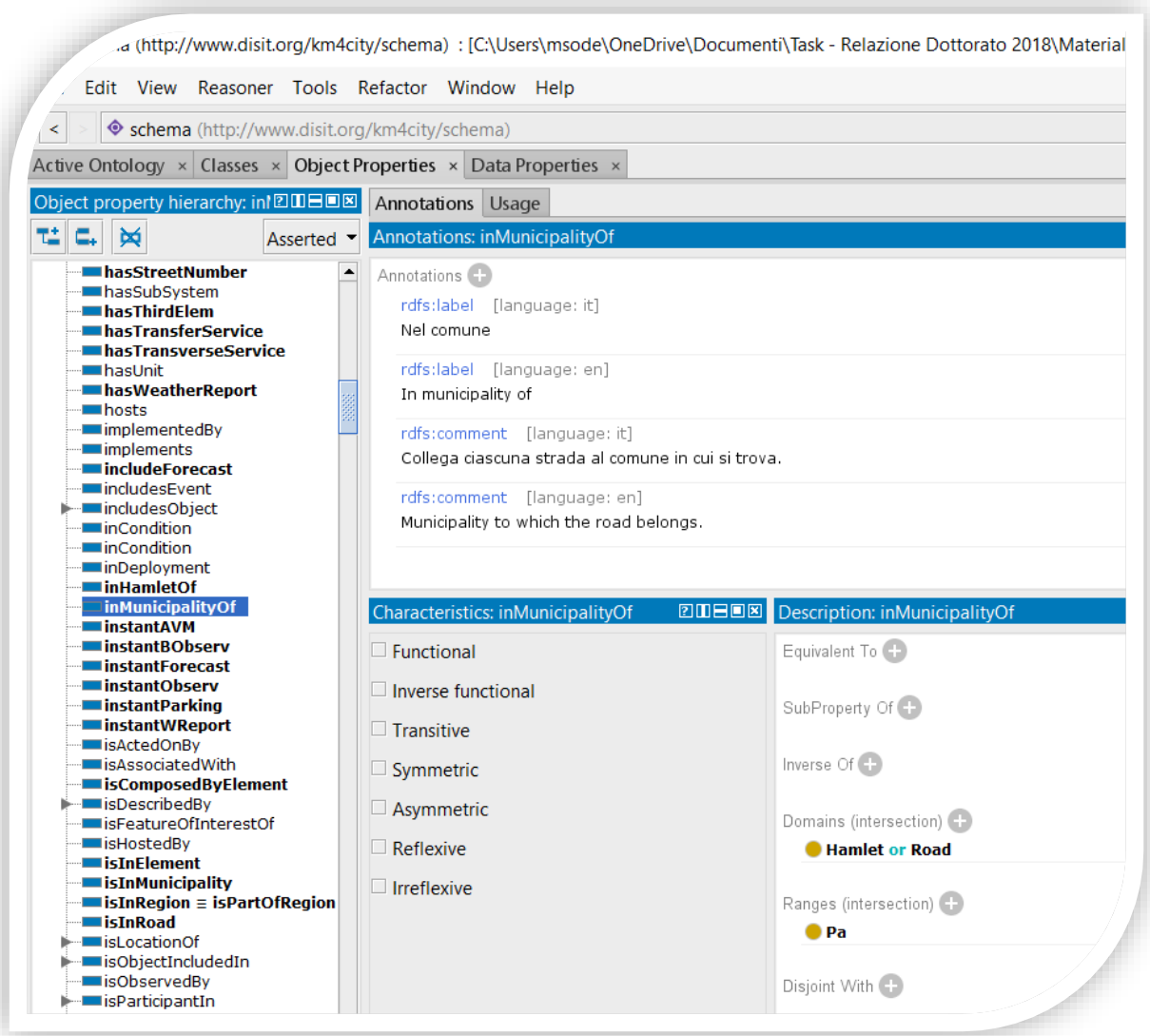


Km4City Ontology: Public Administration



Protégé: Browsing Properties (1)

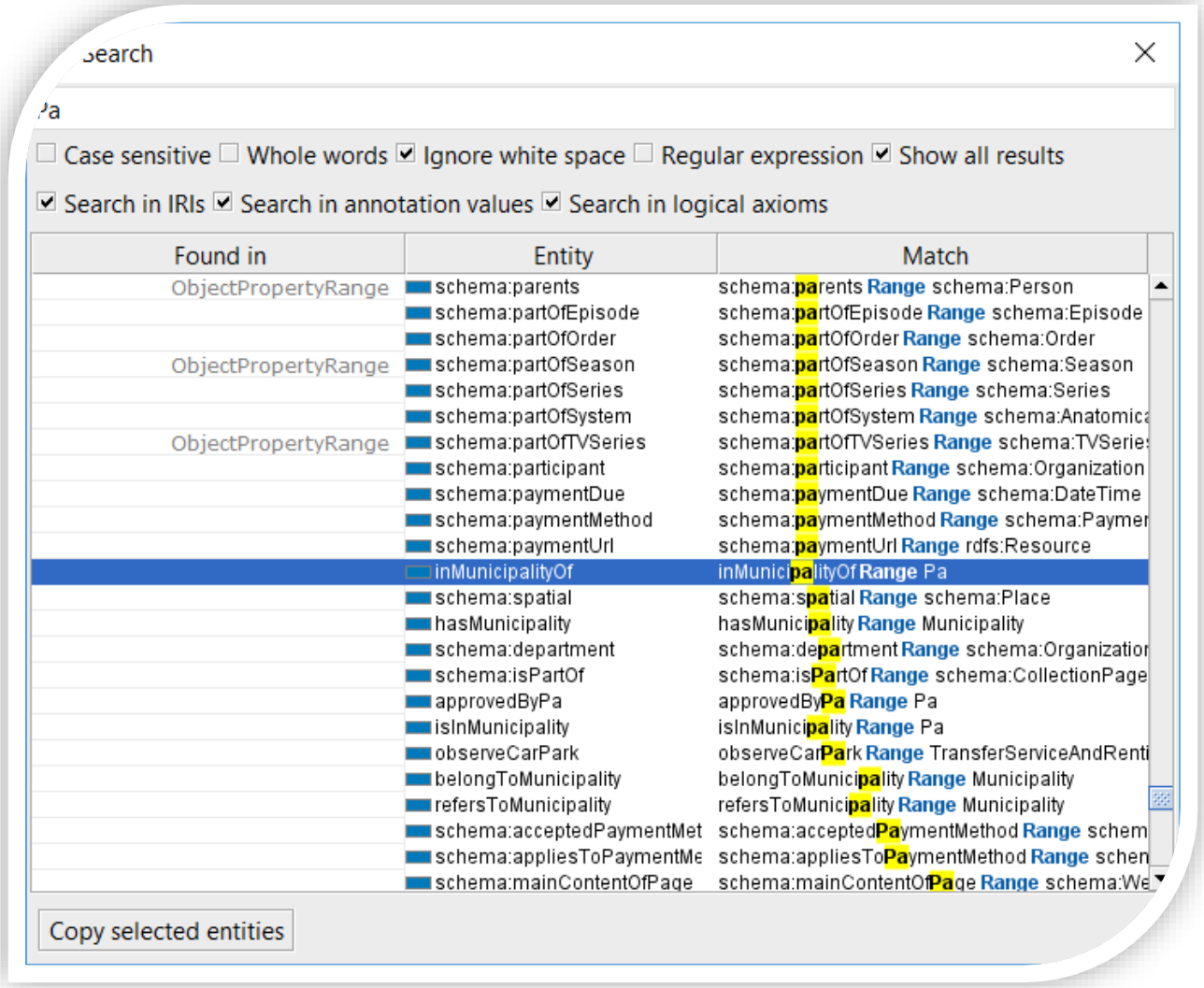
- Properties that relate concepts each other (object properties) can be found in Protégé in the Object Properties tab:
  - Browse to the Object Properties tab
  - Identify the property of interest (use the **Search...** on the top left corner of the Protégé window if needed)
  - Look at the top-right panel (**Annotations**) to learn more about the semantic of the property (metadata such as the label, description, and other, can be found there)
  - Look at the bottom-right panel (**Description**) to discover that resources of type Hamlet, or Road, *can* have the inMunicipalityOf property, whose value is a resource of type Pa



Protégé: Browsing Properties (2)

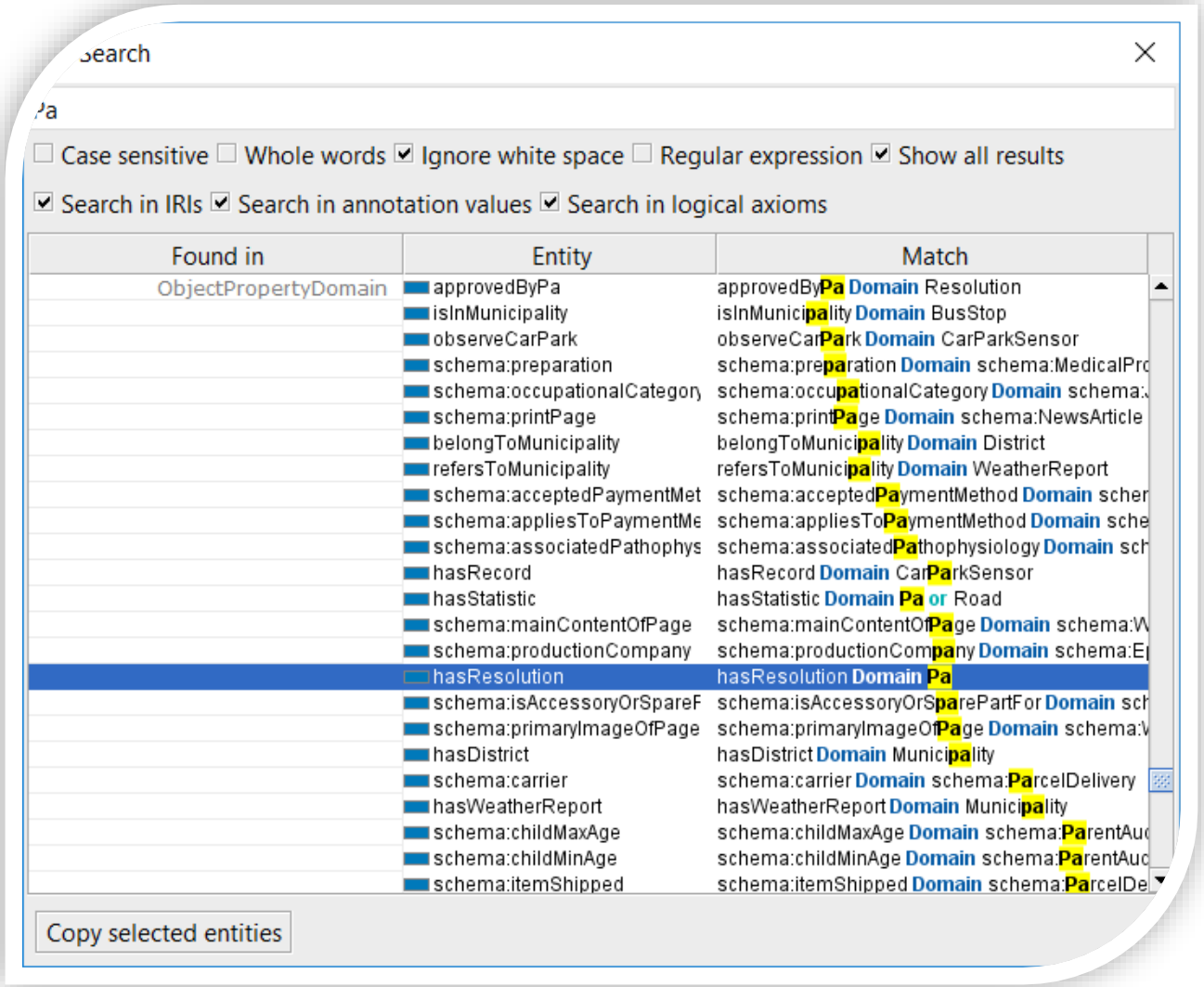
Also, you can use the Protégé Search to identify all properties that are defined for a class, and all properties that are filled by resources of a given class:

- Search for the class name
- Scroll the list of results
- If you look for **Pa**, you will found out, as an example, that among the search result category named **ObjectPropertyRange**, the property inMunicipalityOf appears -> values of the property inMunicipalityOf are resources of type Pa

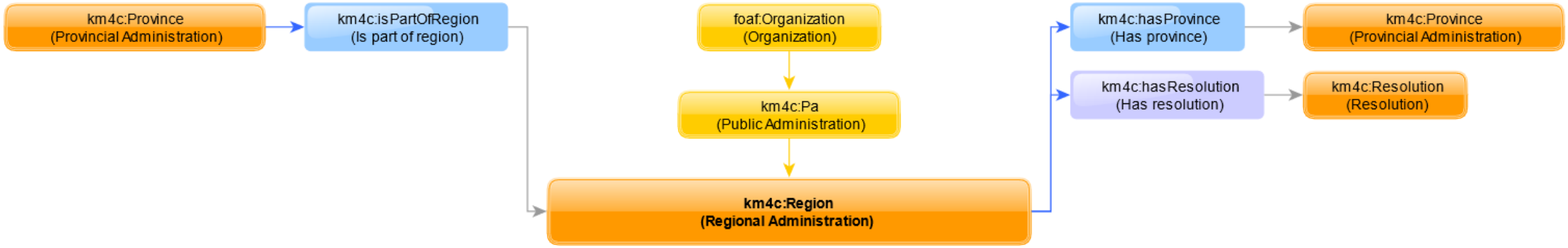


Protégé: Browsing Properties (3)

- The same way, searching for **Pa** and browsing to the **ObjectPropertyDomain** category of results, you will discover that resources of type Pa can have the hasResolution property.

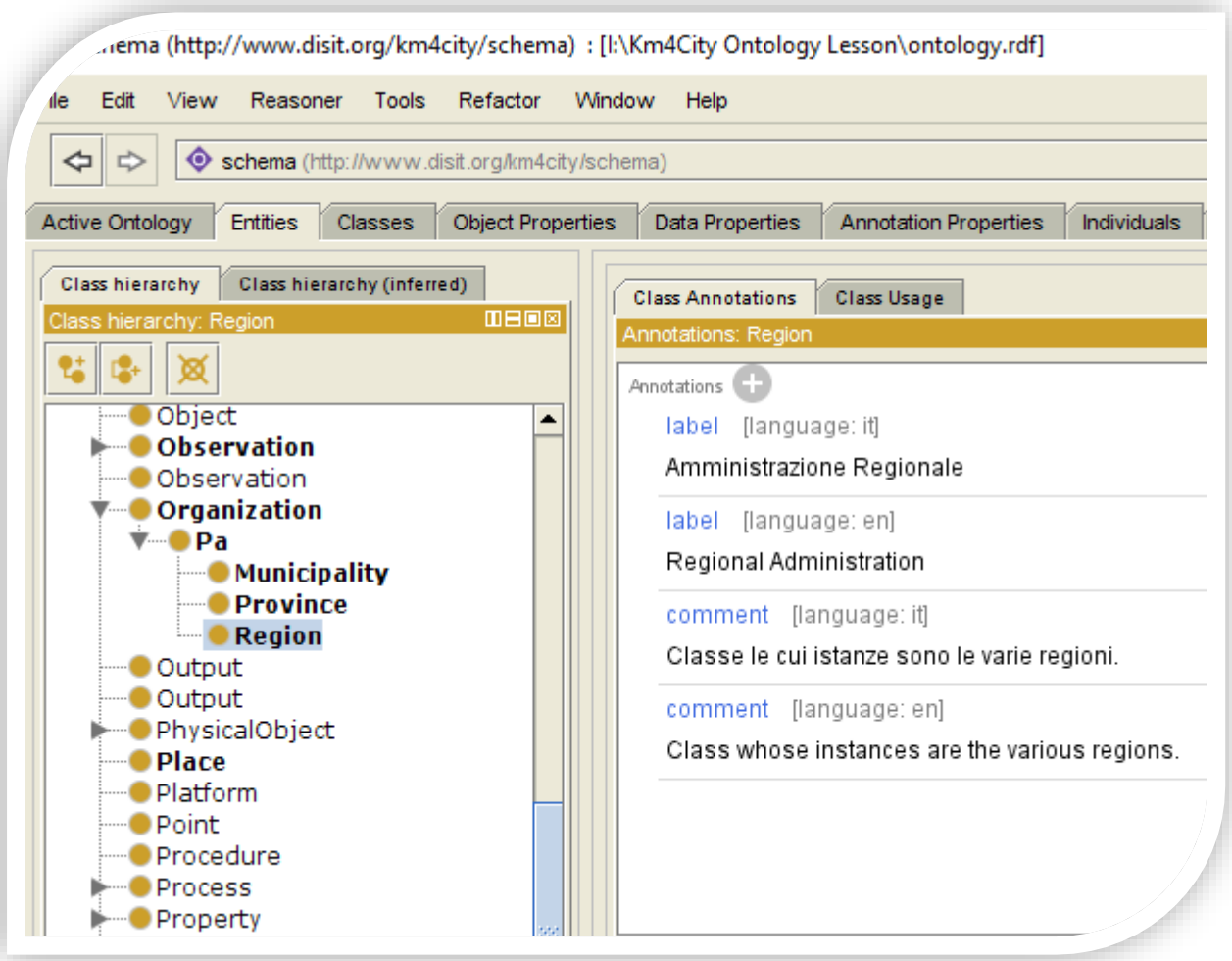


Km4City Ontology: Region



Protégé: Class Meta & Relations

- Let's see how labels, comments, and other metadata about a class, are represented in:
  - **Protegé**
  - Source XML/RDF of the Ontology
  - Km4City KB (triplestore)
- We also see how generalizations and specializations are represented adopting the three different perspectives

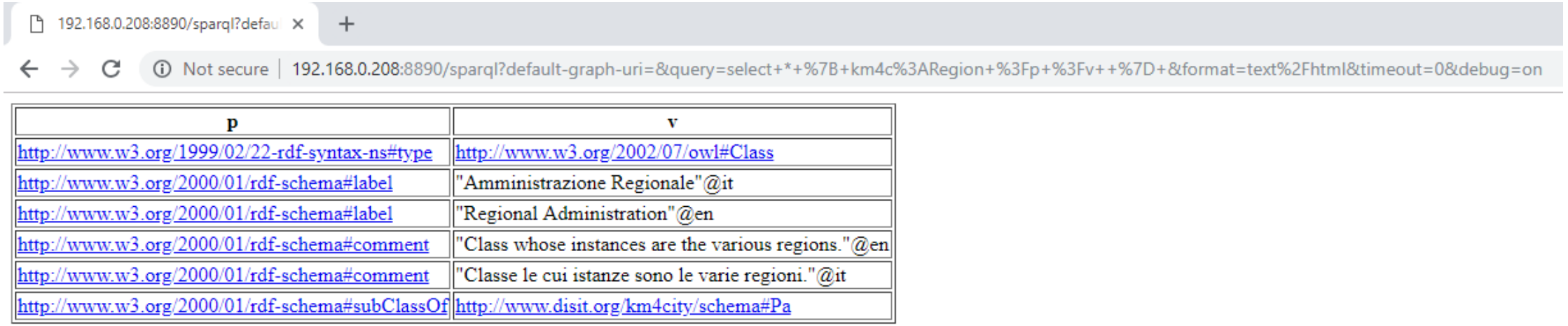


XML/RDF: Class Meta & Relations

```
<!-- http://www.disit.org/km4city/schema#Region -->

<Class rdf:about="&km4c;Region">
    <rdfs:label xml:lang="en">Regional Administration</rdfs:label>
    <rdfs:label xml:lang="it">Amministrazione Regionale</rdfs:label>
    <rdfs:subClassOf rdf:resource="&km4c;Pa"/>
    <rdfs:comment xml:lang="en">Class whose instances are the various regions.</rdfs:comment>
    <rdfs:comment xml:lang="it">Classe le cui istanze sono le varie regioni.</rdfs:comment>
</Class>
```

SPARQL Query: Class Meta & Relations

```
select * { km4c:Region ?p ?v  }

select * { <http://www.disit.org/km4city/schema#Region> ?p ?v  }
```



p	v
http://www.w3.org/1999/02/22-rdf-syntax-ns#type	http://www.w3.org/2002/07/owl#Class
http://www.w3.org/2000/01/rdf-schema#label	"Amministrazione Regionale"@it
http://www.w3.org/2000/01/rdf-schema#label	"Regional Administration"@en
http://www.w3.org/2000/01/rdf-schema#comment	"Class whose instances are the various regions."@en
http://www.w3.org/2000/01/rdf-schema#comment	"Classe le cui istanze sono le varie regioni."@it
http://www.w3.org/2000/01/rdf-schema#subClassOf	http://www.disit.org/km4city/schema#Pa

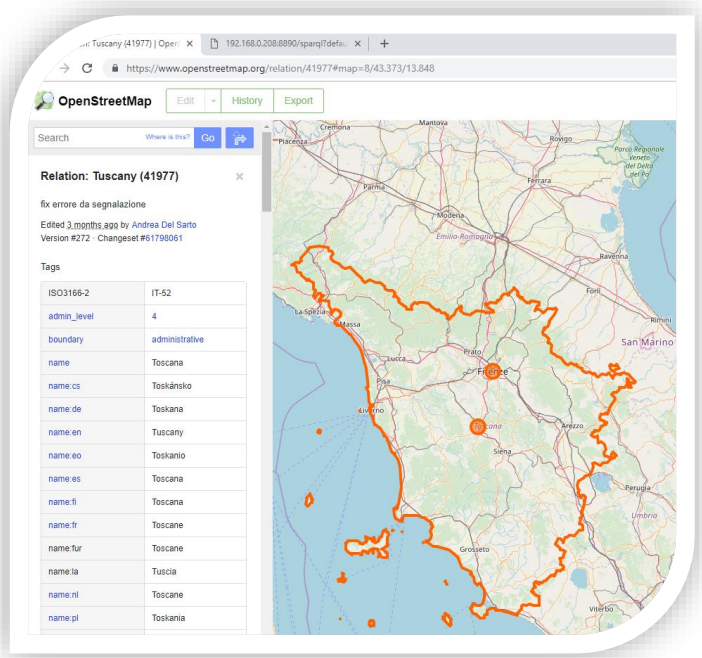
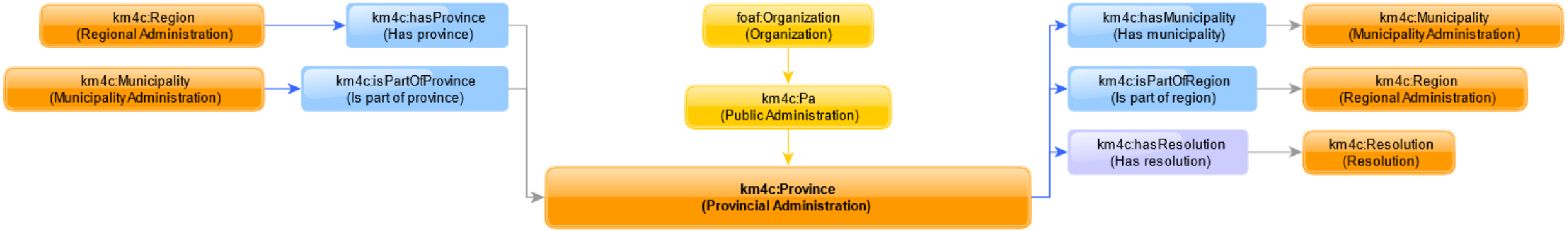
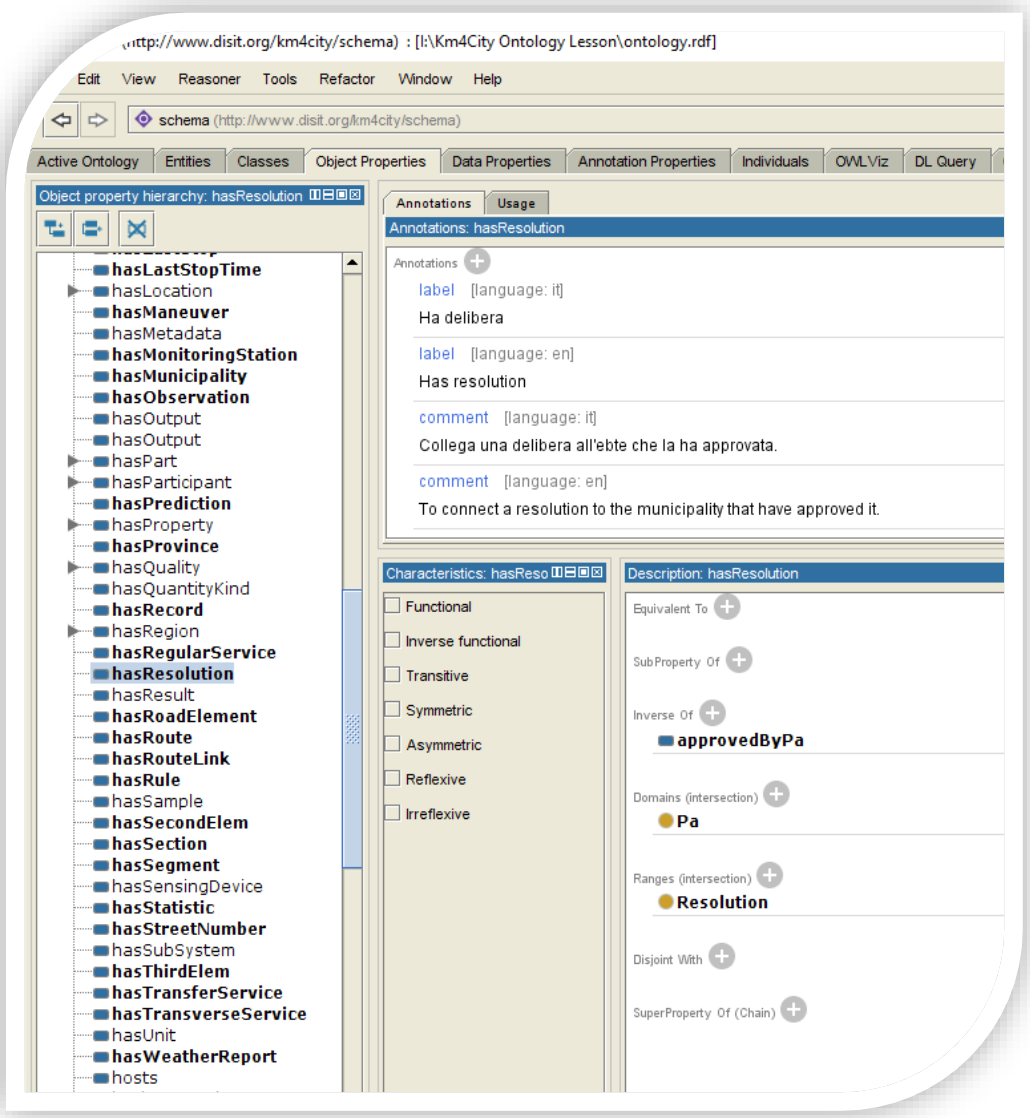
Region *Resource*: Km4City KB vs OSM

Km4City KB

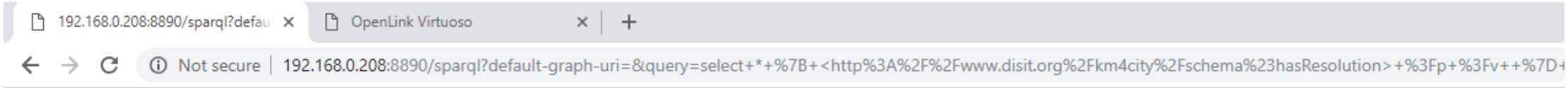
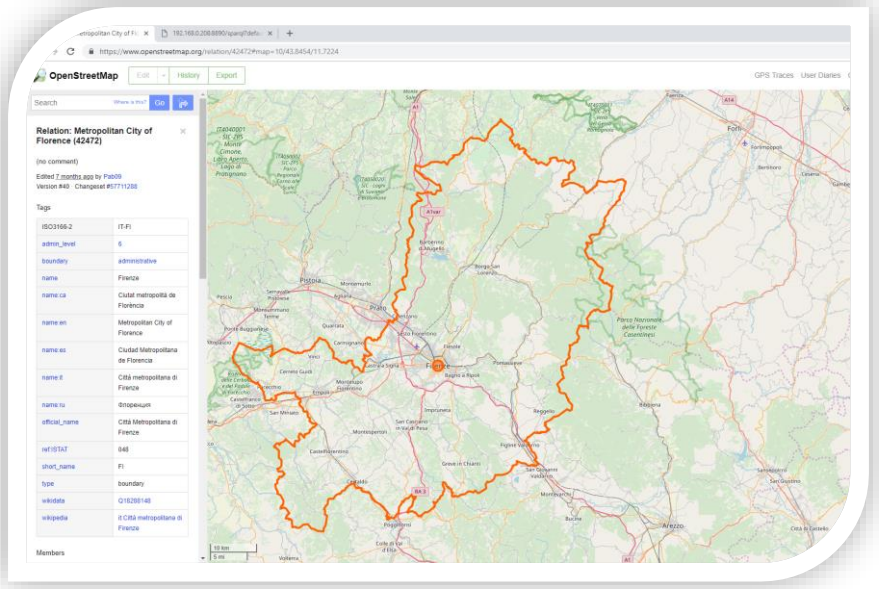
- ```
  select * {
  ?s a km4c:Region;
  foaf:name "Toscana";
  ?p ?v
  }
  ```
- http://192.168.0.208:8890/sparql?default-graph-uri=&query=select+*+%7B+%3Fs+a+km4c%3A**Region**%3B+foaf%3Aname+%22**Toscana**%22%3B+%3Fp+%3Fv+%7D+&format=text%2Fhtml&timeout=0&debug=on
- http://www.disit.org/km4city/resource/OS000000**41977**RG

Open Street Map

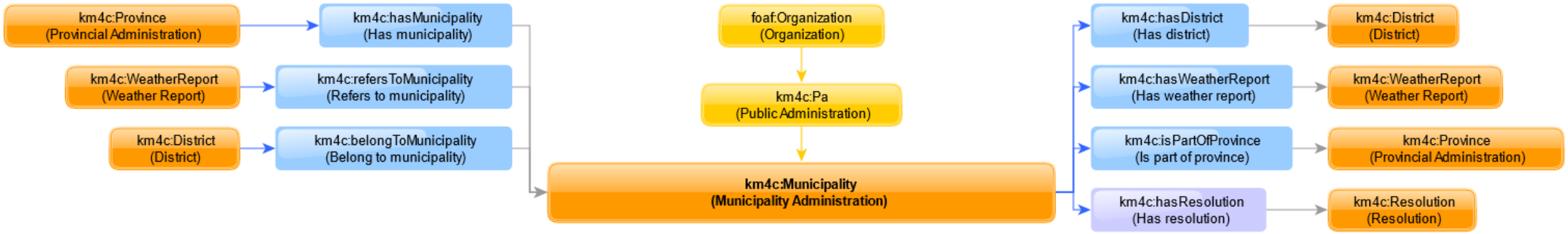
- https://www.openstreetmap.org/relation/**41977**


  ```

Km4City Ontology: Province



Protégé: Object Properties

- The property hasResolution is defined for resources of type Pa
- The Province is defined to be a specialization (a specific type of) Pa
- Therefore, the hasResolution property can also be found on resources of type Province



XML/RDF: Object Properties

```
<!-- http://www.disit.org/km4city/schema#hasResolution -->

<ObjectProperty rdf:about="&km4c;hasResolution">
    <rdfs:label xml:lang="en">Has resolution</rdfs:label>
    <rdfs:label xml:lang="it">Ha delibera</rdfs:label>
    <rdfs:comment xml:lang="en">To connect a resolution to the municipality that have approved it.</rdfs:comment>
    <rdfs:comment xml:lang="it">Collega una delibera all&apos;ebte che la ha approvata.</rdfs:comment>
    <rdfs:domain rdf:resource="&km4c;Pa"/>
    <rdfs:range rdf:resource="&km4c;Resolution"/>
</ObjectProperty>
```

SPARQL Query: Object Properties

```
select * { km4c:hasResolution ?p ?v  }

select * { <http://www.disit.org/km4city/schema#hasResolution> ?p ?v  }
```



p	v
http://www.w3.org/1999/02/22-rdf-syntax-ns#type	http://www.w3.org/2002/07/owl#ObjectProperty
http://www.w3.org/2000/01/rdf-schema#label	"Ha delibera"@it
http://www.w3.org/2000/01/rdf-schema#label	"Has resolution"@en
http://www.w3.org/2000/01/rdf-schema#domain	http://www.disit.org/km4city/schema#Pa
http://www.w3.org/2000/01/rdf-schema#range	http://www.disit.org/km4city/schema#Resolution
http://www.w3.org/2000/01/rdf-schema#comment	"Collega una delibera all'ebte che la ha approvata."@it
http://www.w3.org/2000/01/rdf-schema#comment	"To connect a resolution to the municipality that have approved it."@en

Province *Resource*: Km4City KB vs OSM

Km4City KB

- ```
  select * {
  ?s a km4c:Province;
  foaf:name "Firenze";
  ?p ?v
  }
  ```
- http://192.168.0.208:8890/sparql?default-graph-uri=&query=select+*+%7B+%3Fs+a+km4c%3A**Province**%3B+foaf%3Aname+%22**Firenze**%22%3B+%3Fp+%3Fv+%7D+&format=text%2Fhtml&timeout=0&debug=on
- http://www.disit.org/km4city/resource/OS000000**42472**PR

Open Street Map

- https://www.openstreetmap.org/relation/**42472**


  ```

Km4City Ontology: Municipality



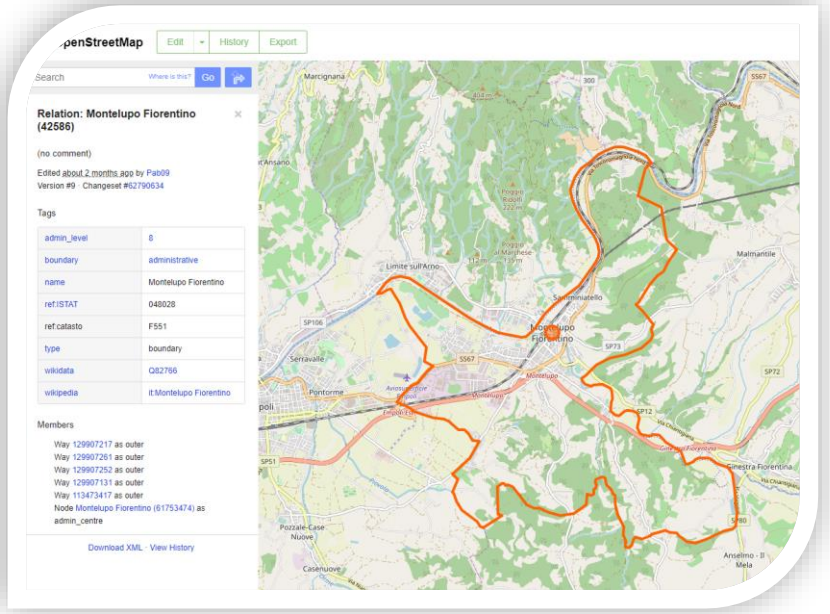
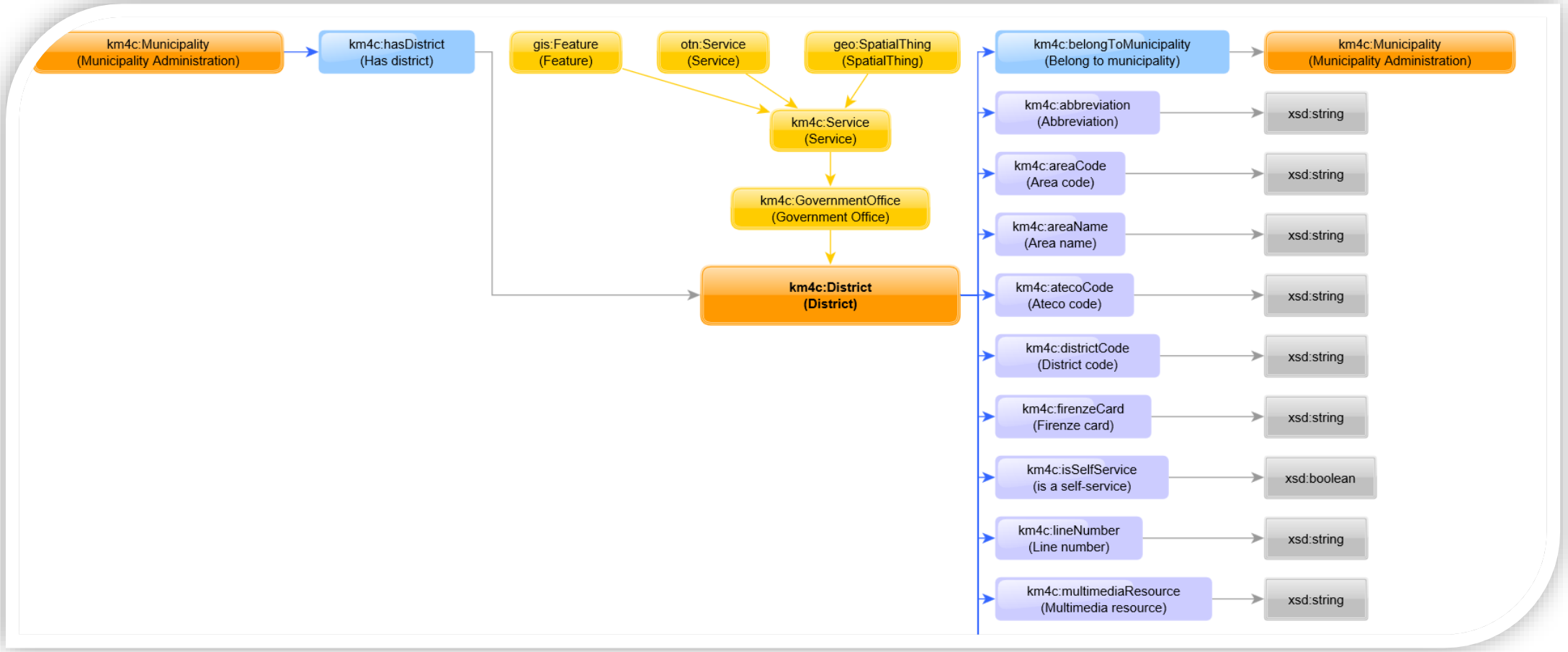
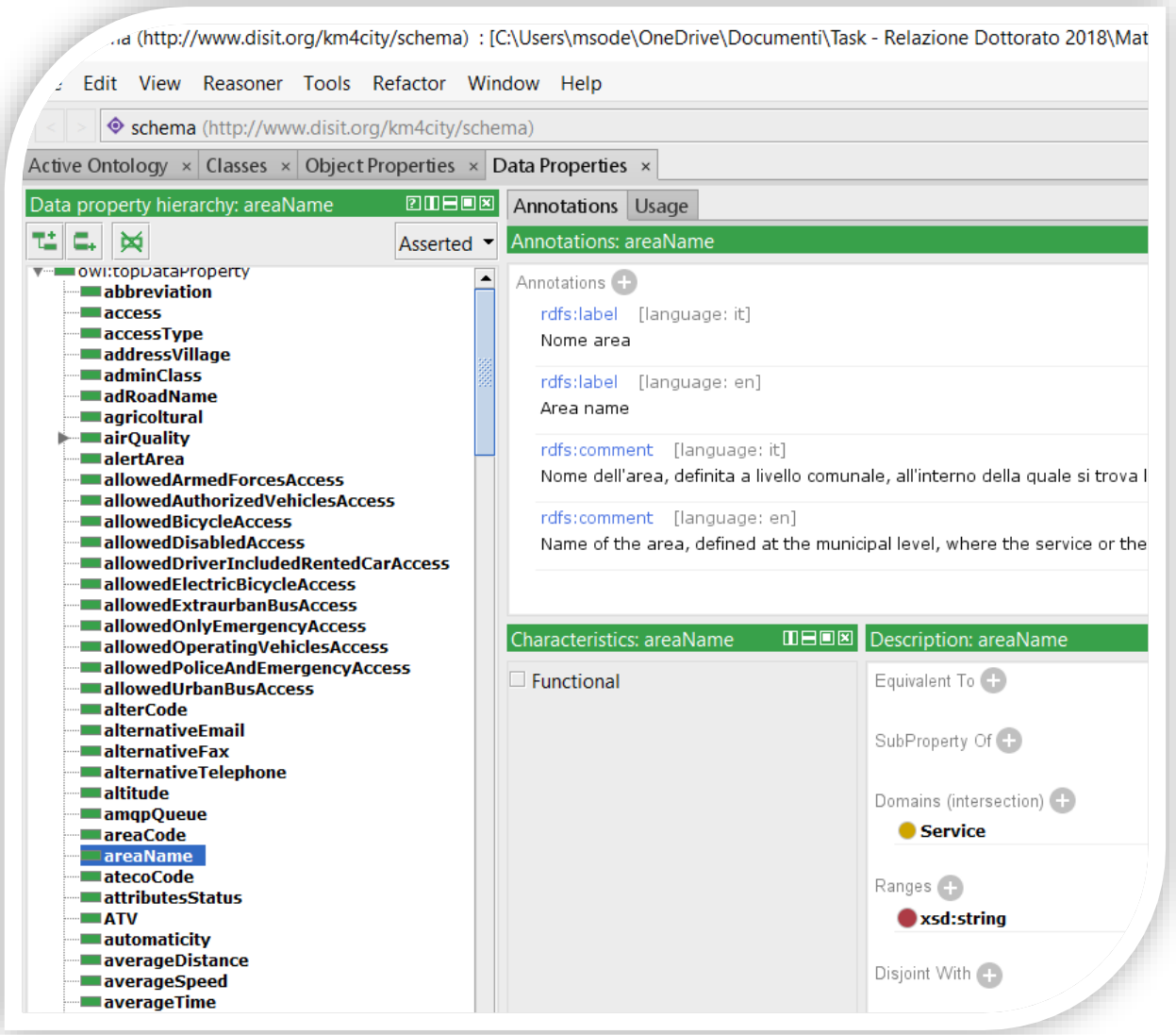
Municipality *Resource*: Km4City KB vs OSM

Km4City KB

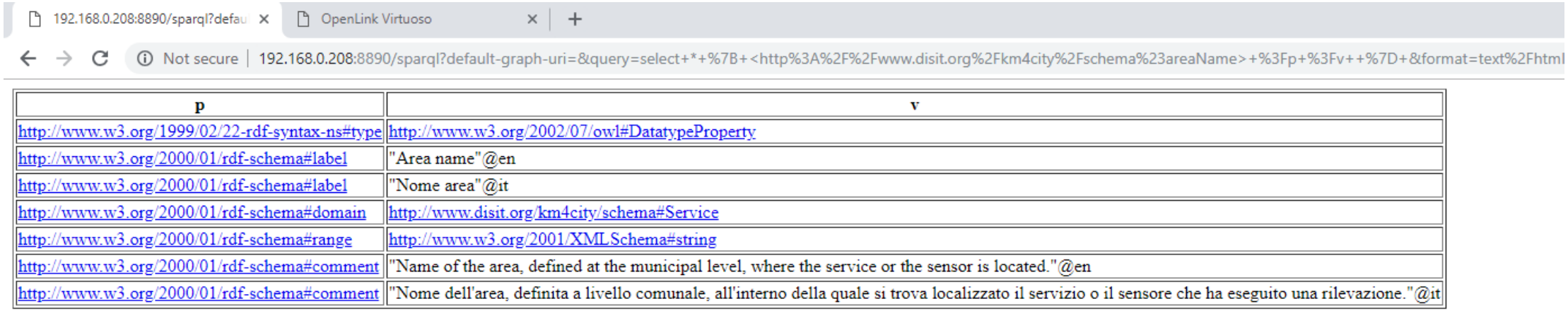
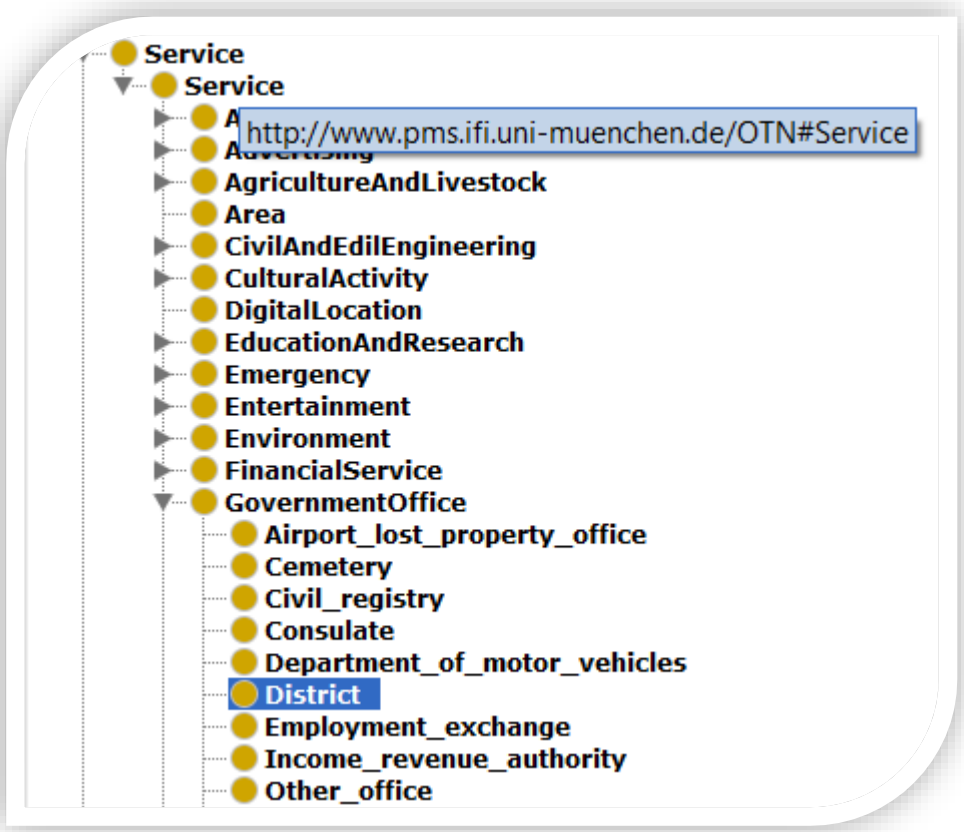
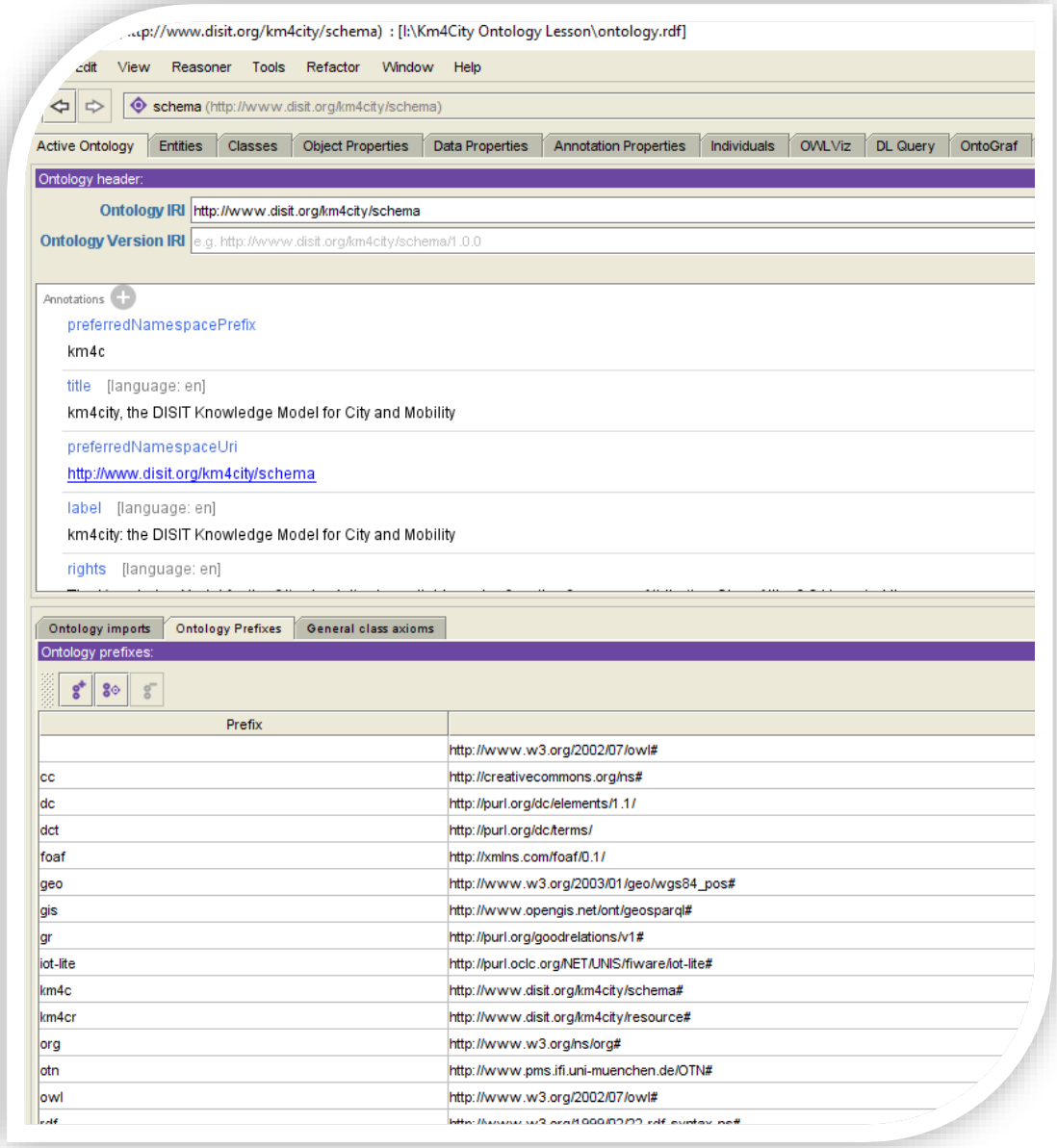
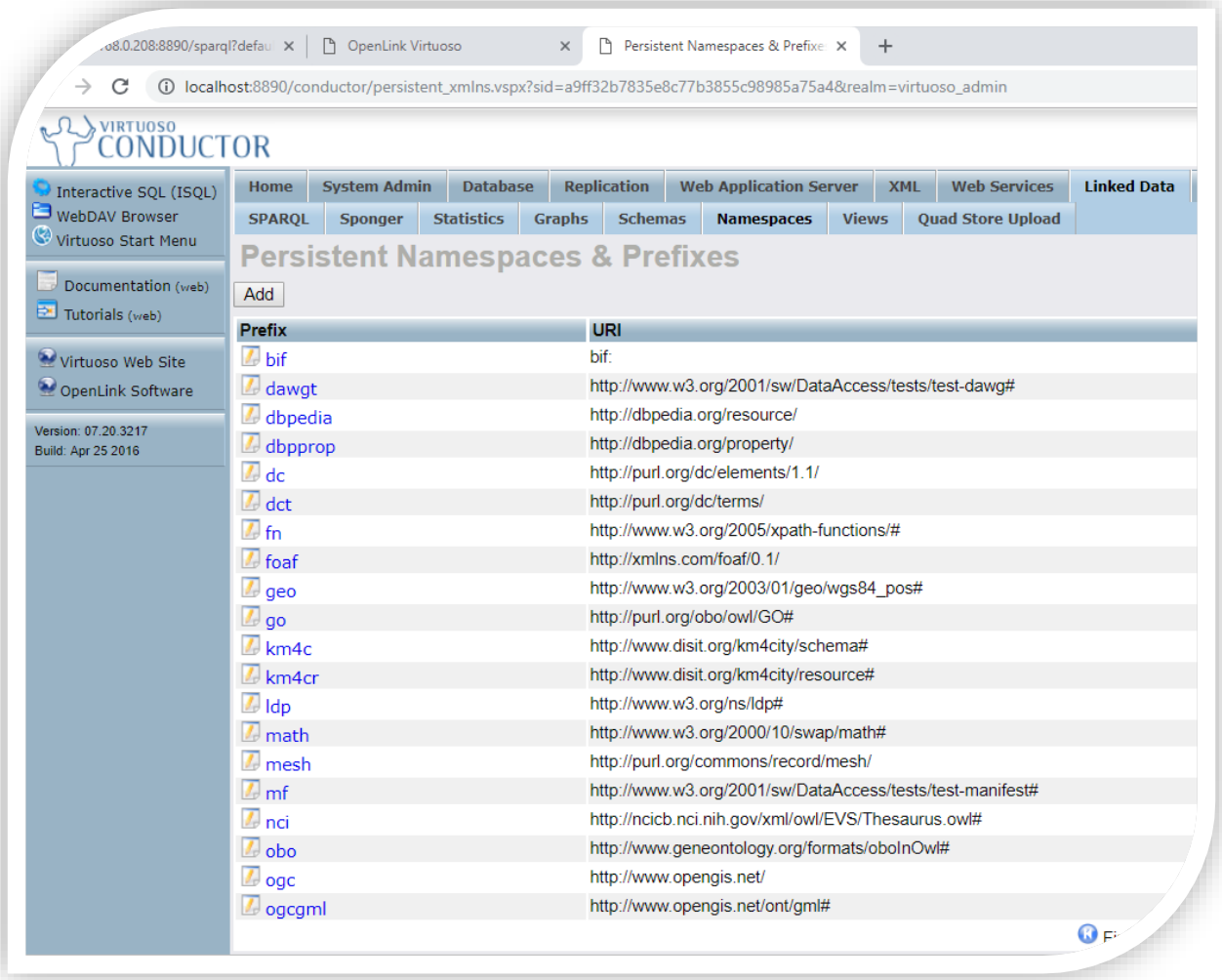
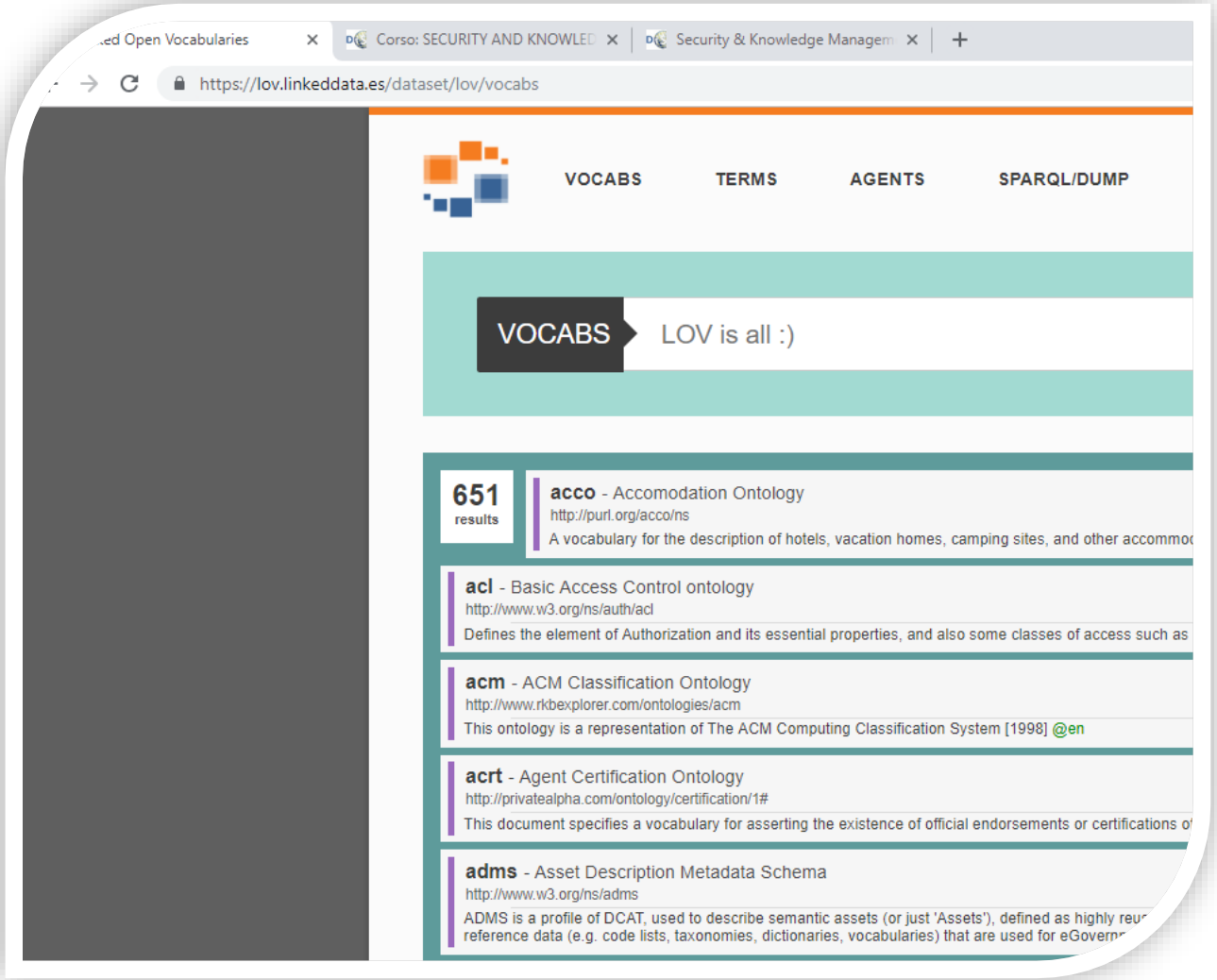
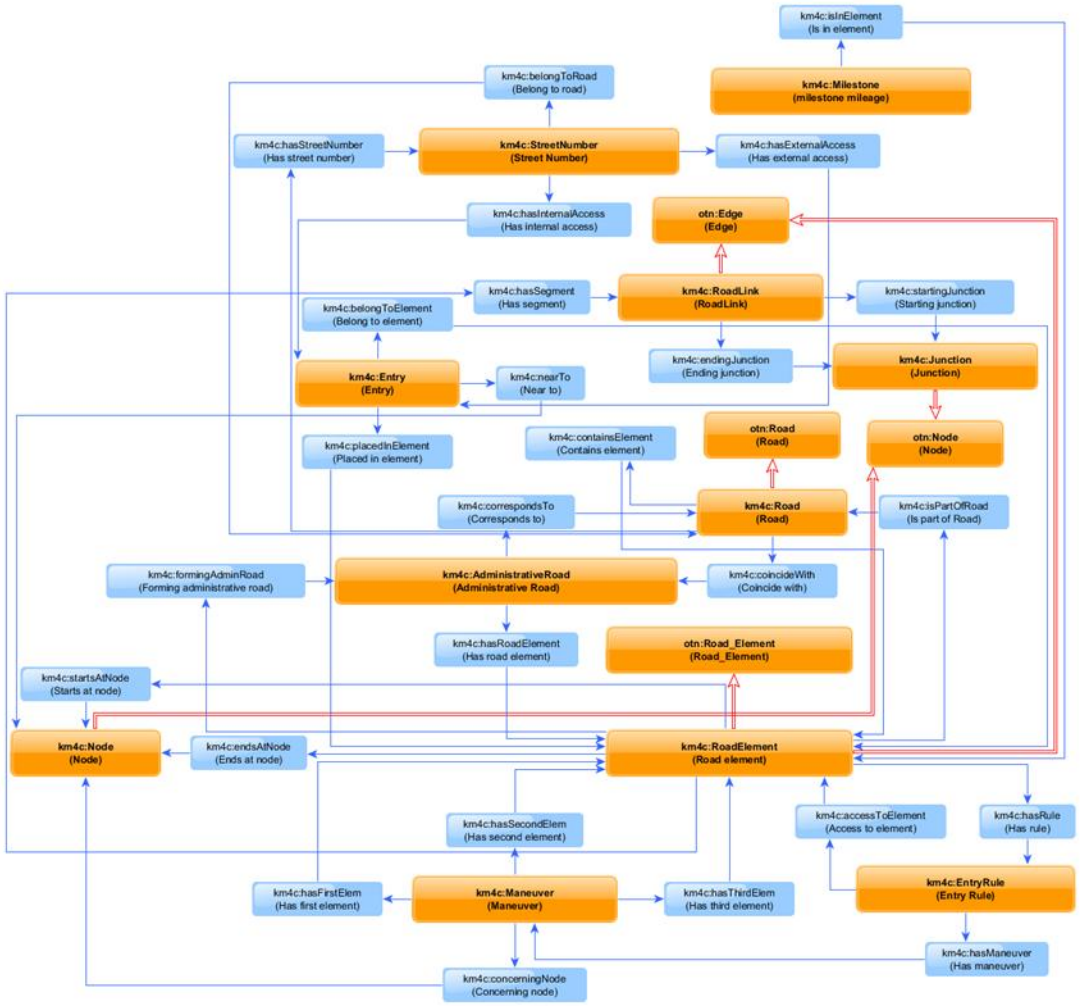
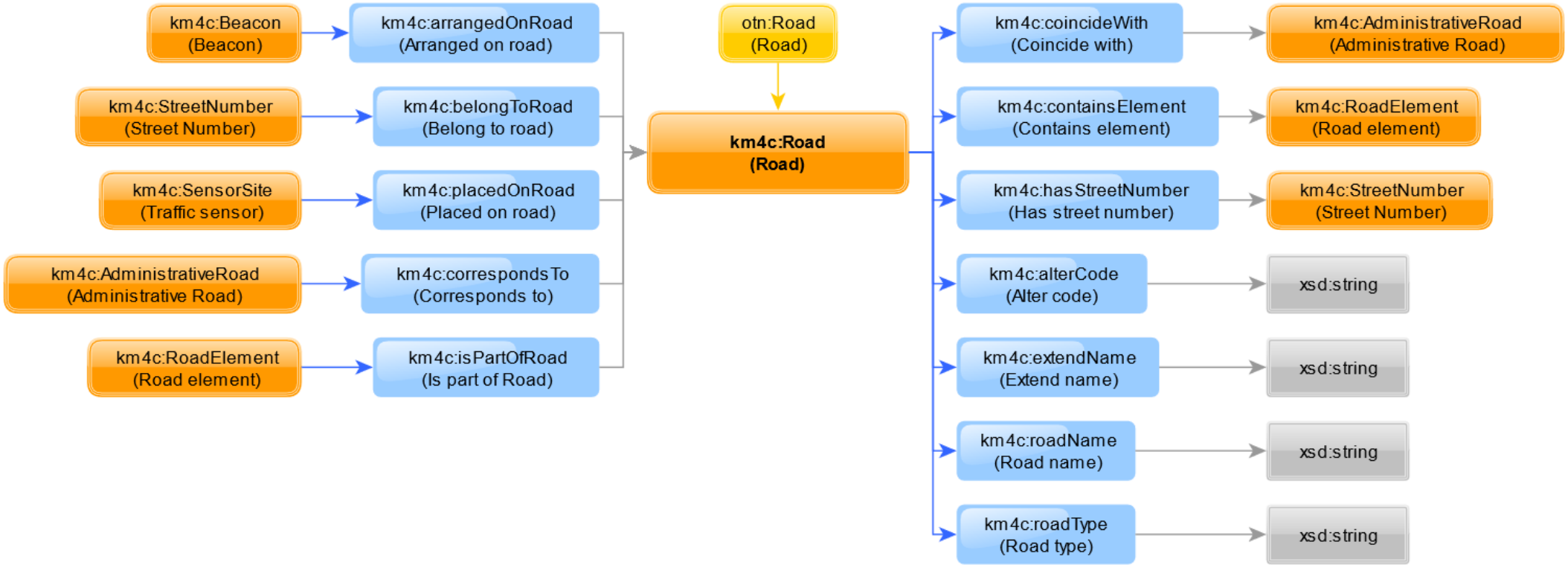
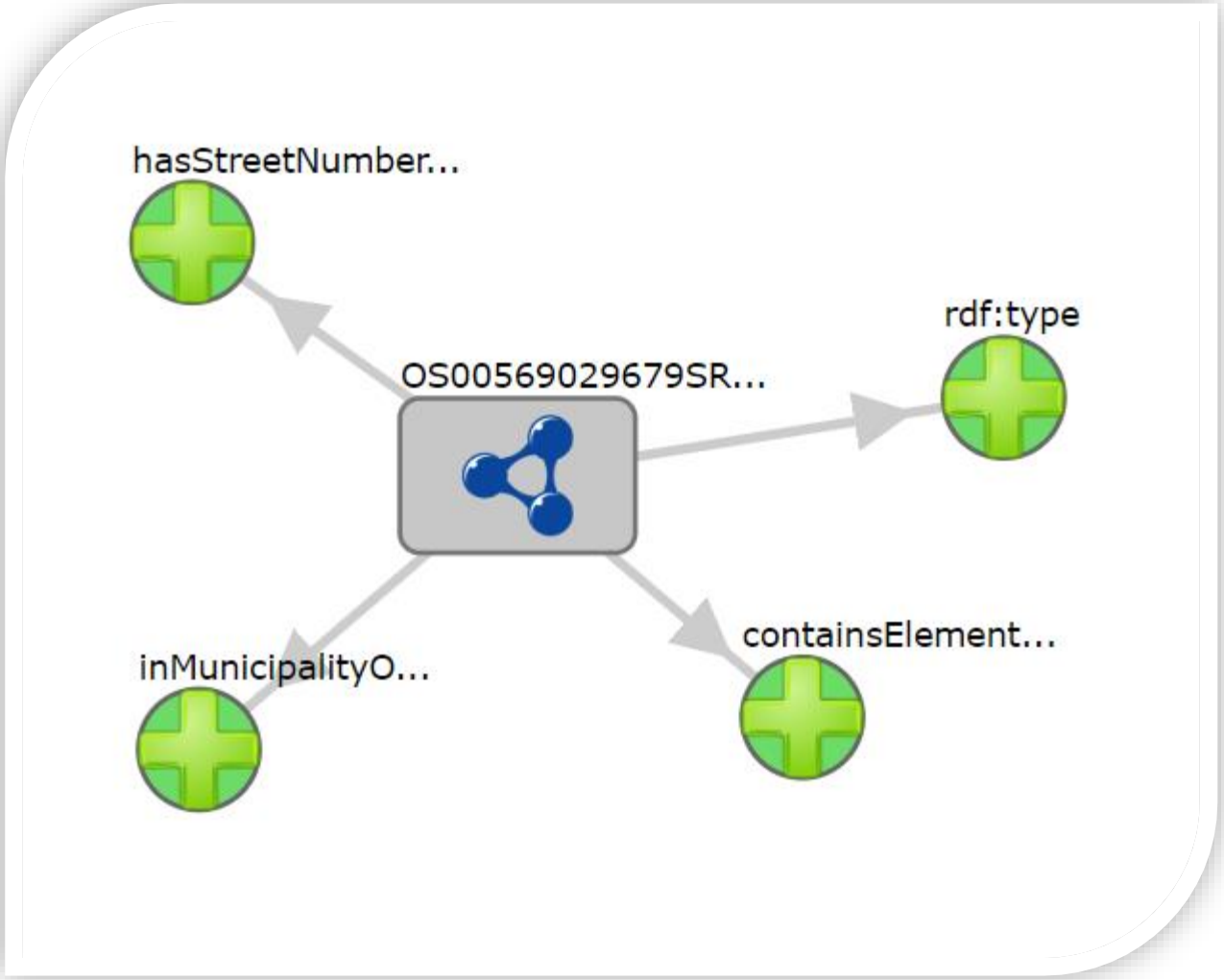
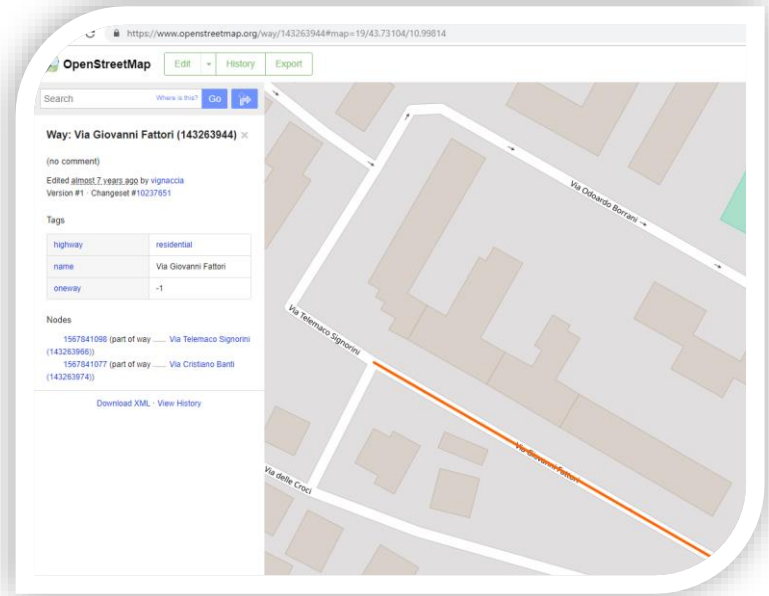
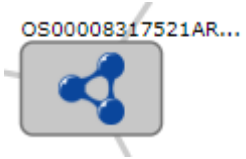
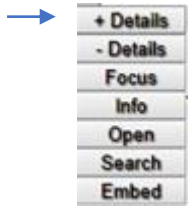
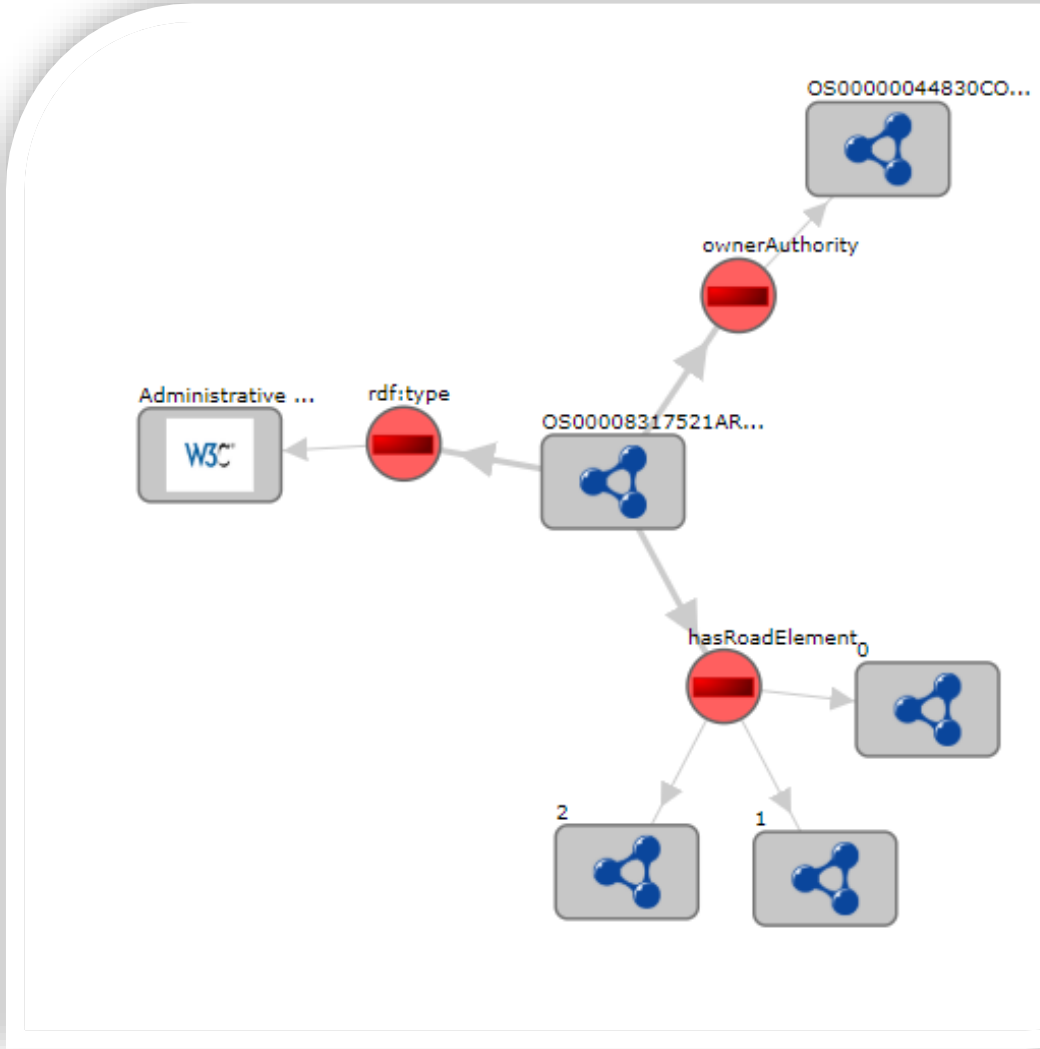
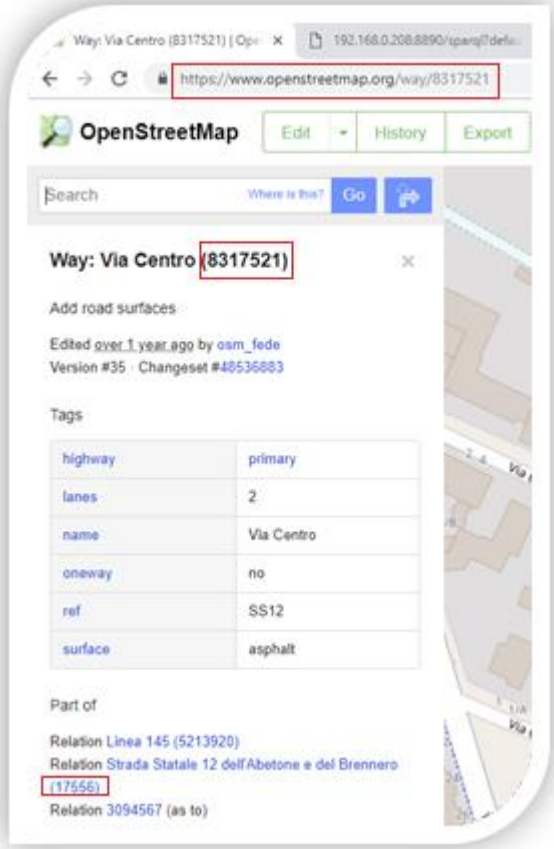
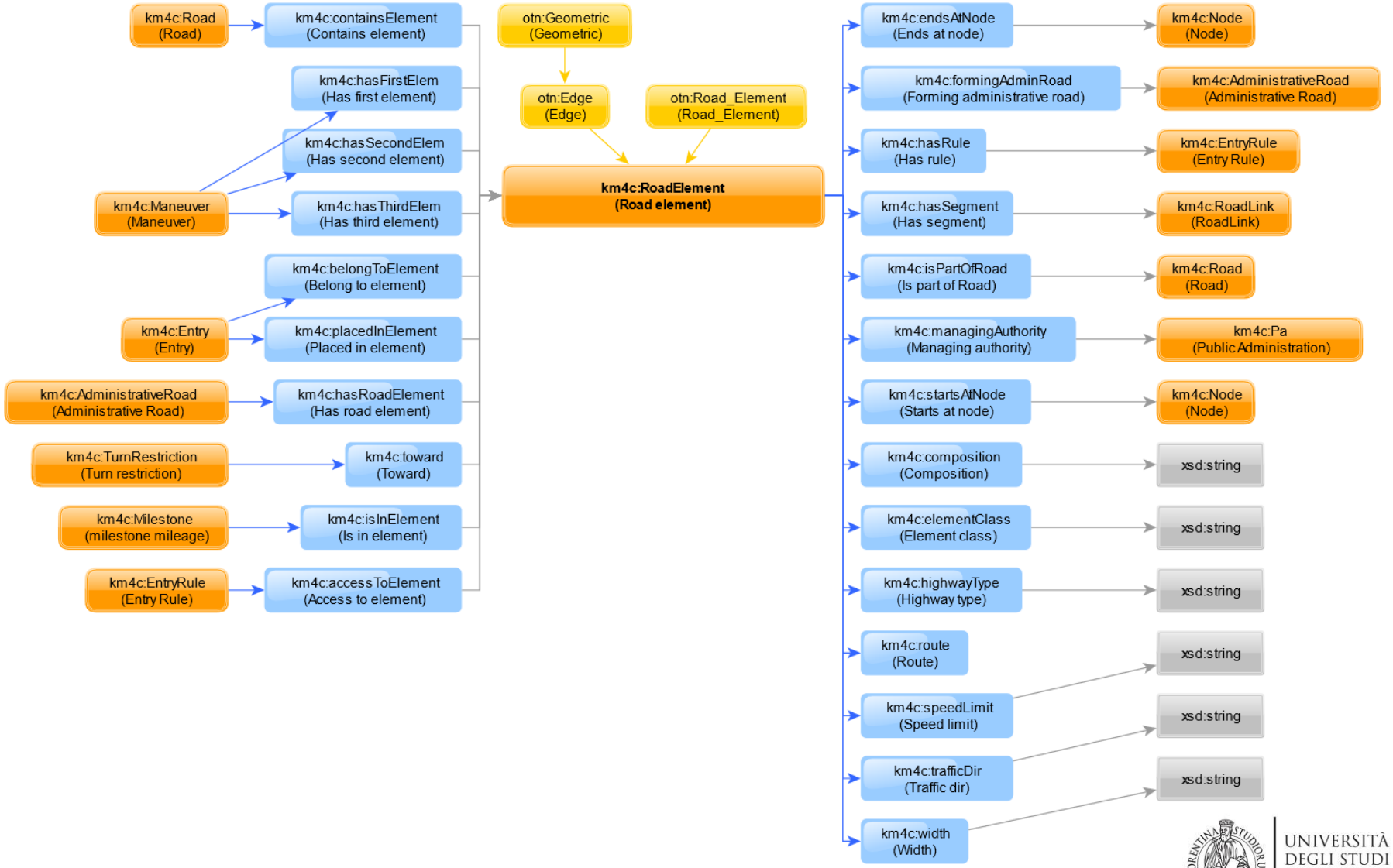
- ```
  select * {
  ?s a km4c:Municipality;
  foaf:name "Montelupo Fiorentino";
  ?p ?v
  }
  ```
- http://192.168.0.208:8890/sparql?default-graph-uri=&query=select+*+%7B+%3Fs+a+km4c%3A**Municipality**%3B+foaf%3Aname+%**22Montelupo+Fiorentino**%22%3B+%3Fp+%3Fv+%7D+&format=text%2Fhtml&timeout=0&debug=on
- http://www.disit.org/km4city/resource/OS000000**42586**CO

Open Street Map

- https://www.openstreetmap.org/relation/**42586**


  ```

Km4City Ontology: District



Protégé: Data Properties

- Full details about data properties can be found in Protégé:
  - Open the Data Properties tab
  - Find the data property of your interest
  - Look at the top-right (**Annotations**) panel to learn about the semantic of the data property (label, description, and other)
  - Look at the bottom-right (**Description**) panel to discover that, as an example, the **areaName** property is a data property that can be found in **Service** resources, and to discover that values of the areaName property are text **strings**
  - Since **the District is a Service**, the areaName property can be found in District resources



XML/RDF: Data Properties

```
<!-- http://www.disit.org/km4city/schema#areaName -->

<DatatypeProperty rdf:about="&km4c;areaName">
    <rdfs:label xml:lang="en">Area name</rdfs:label>
    <rdfs:label xml:lang="it">Nome area</rdfs:label>
    <rdfs:comment xml:lang="en">Name of the area, defined at the municipal level, where the service or the sensor is located.</rdfs:comment>
    <rdfs:comment xml:lang="it">Nome dell&apos;area, definita a livello comunale, all&apos;interno della quale si trova
    localizzato il servizio o il sensore che ha eseguito una rilevazione.</rdfs:comment>
    <rdfs:domain rdf:resource="&km4c;Service"/>
    <rdfs:range rdf:resource="&xsd;string"/>
</DatatypeProperty>
```

SPARQL Query: Data Properties

```
select * { km4c:areaName ?p ?v  }

select * { <http://www.disit.org/km4city/schema#areaName> ?p ?v  }
```



p	v
http://www.w3.org/1999/02/22-rdf-syntax-ns#type	http://www.w3.org/2002/07/owl#DatatypeProperty
http://www.w3.org/2000/01/rdf-schema#label	"Area name"@en
http://www.w3.org/2000/01/rdf-schema#label	"Nome area"@it
http://www.w3.org/2000/01/rdf-schema#domain	http://www.disit.org/km4city/schema#Service
http://www.w3.org/2000/01/rdf-schema#range	http://www.w3.org/2001/XMLSchema#string
http://www.w3.org/2000/01/rdf-schema#comment	"Name of the area, defined at the municipal level, where the service or the sensor is located."@en
http://www.w3.org/2000/01/rdf-schema#comment	"Nome dell'area, definita a livello comunale, all'interno della quale si trova localizzato il servizio o il sensore che ha eseguito una rilevazione."@it

Reusing vocabularies: the Service example

- District *is a* Service
- The http://www.disit.org/km4city/schema#Service is a http://www.pms.ifi.uni-muenchen.de/OTN#Service
- http://www.pms.ifi.uni-muenchen.de/OTN#Service is a class that is not *defined* in the Km4City Ontology (indeed, you can see that its URI does not starts with http://www.disit.org/km4city/schema#)
- http://www.pms.ifi.uni-muenchen.de/OTN#Service is a class that is defined in the OTN vocabulary, that is *reused* in the Km4City Ontology
- Reusing well-known vocabularies is a recommended practice that helps the interoperability and the building of applications that spread across multiple triplestores



Protégé: Vocabularies, and Prefixes

- Open the **Active Ontology** tab
- Open the **Ontology Prefixes** tab in the bottom panel



RDF/XML: Vocabularies, and Prefixes

```
<!DOCTYPE rdf:RDF [
    <!ENTITY schema "http://schema.org/" >
    <!ENTITY org "http://www.w3.org/ns/org#" >
    <!ENTITY vocab "http://vocab.sindice.net/" >
    <!ENTITY dct "http://purl.org/dc/terms/" >
    <!ENTITY foaf "http://xmlns.com/foaf/0.1/" >
    <!ENTITY ssn "https://www.w3.org/ns/ssn/" >
    <!ENTITY vann "http://purl.org/vocab/vann/" >
    <!ENTITY time "http://www.w3.org/2006/time#" >
    <!ENTITY cc "http://creativecommons.org/ns#" >
    <!ENTITY owl "http://www.w3.org/2002/07/owl#" >
    <!ENTITY dc "http://purl.org/dc/elements/1.1/" >
    <!ENTITY gr "http://purl.org/goodrelations/v1#" >
    <!ENTITY xsd "http://www.w3.org/2001/XMLSchema#" >
    <!ENTITY skos "http://www.w3.org/2004/02/skos/core#" >
    <!ENTITY km4c "http://www.disit.org/km4city/schema#" >
    <!ENTITY gis "http://www.opengis.net/ont/geosparql#" >
    <!ENTITY rdfs "http://www.w3.org/2000/01/rdf-schema#" >
    <!ENTITY km4cr "http://www.disit.org/km4city/resource#" >
    <!ENTITY otn "http://www.pms.ifi.uni-muenchen.de/OTN#" >
    <!ENTITY geo "http://www.w3.org/2003/01/geo/wgs84_pos#" >
    <!ENTITY rdf "http://www.w3.org/1999/02/22-rdf-syntax-ns#" >
    <!ENTITY iot-lite "http://purl.oclc.org/NET/UNIS/fiware/iot-lite#" >
]>
```

Virtuoso: Vocabs, and Prefixes

- For that you could make use of namespaces (abbreviated URIs) in SPARQL queries that you submit to Virtuoso, you have to add them in Virtuoso Conductor, the Web interface of Virtuoso server instances dedicated to administrators



Vocabularies: How to Learn More

- Linked Open Vocabularies is a good place to start when you need some further information about a vocabulary, or a vocabulary term:

  https://lov.linkeddata.es/dataset/lov

- A SPARQL Endpoint is also available from where you can query the Linked Open Vocabularies:

  https://lov.linkeddata.es/dataset/lov/sparql



Km4City Ontology: Street Graph (Basics)

- Road
- AdministrativeRoad
- RoadElement
- Node
- StreetNumber
- Entry
- …



Km4City Ontology: Road



DISIT LOG: Object Properties of a Resource

https://log.disit.org/service/index.php?uri=**http://www.disit.org/km4city/resource/OS00569029679SR**&sparql=http://192.168.0.208:8890/sparql



SPARQL Query: Object Properties (of a given Resource)

```
select distinct ?p {
    <http://www.disit.org/km4city/resource/OS00569029679SR> ?p ?v .
    ?v a ?vClass
}
```

p
http://www.disit.org/km4city/schema#hasStreetNumber
http://www.disit.org/km4city/schema#containsElement
http://www.w3.org/1999/02/22-rdf-syntax-ns#type
http://www.disit.org/km4city/schema#inMunicipalityOf

Road *Resource*: Km4City KB vs OSM

Km4City KB

- `select * { <http://www.disit.org/km4city/resource/OS00143263944SR> ?p ?v }`
- http://192.168.0.208:8890/sparql?default-graph-uri=&query=select+*+%7B+%3Chttp%3A%2F%2Fwww.disit.org%2Fkm4city%2Fresource%2FOS00143263944SR%3E+%3Fp+%3Fv+%7D%0D%0A

p	v
http://www.w3.org/1999/02/22-rdf-syntax-ns#type	http://www.disit.org/km4city/schema#Road
http://purl.org/dc/terms/identifier	"OS00143263944SR"
http://www.disit.org/km4city/schema#containsElement	http://www.disit.org/km4city/resource/OS00143263944RE/0
http://www.disit.org/km4city/schema#extendName	"Via Giovanni Fattori"
http://www.disit.org/km4city/schema#inMunicipalityOf	http://www.disit.org/km4city/resource/OS00000042586CO
http://www.disit.org/km4city/schema#roadName	"Giovanni Fattori"
http://www.disit.org/km4city/schema#roadType	"via"

Open Street Map

- https://www.openstreetmap.org/way/**143263944**



Km4City Ontology: AdministrativeRoad

DISIT LOG: Values of Object Properties of a Resource

https://log.disit.org/service/index.php?uri=**http://www.disit.org/km4city/resource/OS00000017556LR/OS00008317521AR**&sparql=http://192.168.0.208:8890/sparql

1. Right Click on:



2. And hit **+ Details**





SPARQL Query: Values of Object Properties (of a given Resource)

```
select distinct ?p ?v {
    <http://www.disit.org/km4city/resource/OS00000017556LR/OS00008317521AR> ?p ?v .
    ?v a ?vClass
}
```

p	v
http://www.w3.org/1999/02/22-rdf-syntax-ns#type	http://www.disit.org/km4city/schema#AdministrativeRoad
http://www.disit.org/km4city/schema#ownerAuthority	http://www.disit.org/km4city/resource/OS00000044830CO
http://www.disit.org/km4city/schema#hasRoadElement	http://www.disit.org/km4city/resource/OS00008317521RE/0
http://www.disit.org/km4city/schema#hasRoadElement	http://www.disit.org/km4city/resource/OS00008317521RE/1
http://www.disit.org/km4city/schema#hasRoadElement	http://www.disit.org/km4city/resource/OS00008317521RE/2

AdministrativeRoad *Resource*: KM4C KB vs OSM

Km4City KB

- `select * { <http://www.disit.org/km4city/resource/OS00000**17556**LR/OS0000**8317521**AR> ?p ?v }`
- `http://192.168.0.208:8890/sparql?default-graph-uri=&query=select+*+%7B+%3Chttp%3A%2F%2Fwww.disit.org%2Fkm4city%2Fresource%2FOS00000**17556**LR%2FOS0000**8317521**AR%3E+%3Fp+%3Fv+%7D&format=text%2Fhtml&timeout=0&debug=on`

p	v
http://www.w3.org/1999/02/22-rdf-syntax-ns#type	http://www.disit.org/km4city/schema#AdministrativeRoad
http://purl.org/dc/terms/alternative	"Strada Statale 12 dell'Abetone e del Brennero"
http://purl.org/dc/terms/identifier	"OS00000017556LR/OS00008317521AR"
http://www.disit.org/km4city/schema#adRoadNameGeneric	"via"
http://www.disit.org/km4city/schema#adRoadNameSpecific	"Centro"
http://www.disit.org/km4city/schema#adRoadName	"Via Centro"
http://www.disit.org/km4city/schema#adminClass	"strada statale"
http://www.disit.org/km4city/schema#hasRoadElement	http://www.disit.org/km4city/resource/OS00008317521RE/0
http://www.disit.org/km4city/schema#hasRoadElement	http://www.disit.org/km4city/resource/OS00008317521RE/1
http://www.disit.org/km4city/schema#hasRoadElement	http://www.disit.org/km4city/resource/OS00008317521RE/2
http://www.disit.org/km4city/schema#ownerAuthority	http://www.disit.org/km4city/resource/OS00000044830CO

Open Street Map



Km4City Ontology: RoadElement



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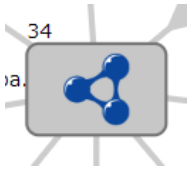
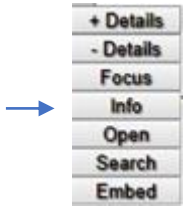
DINFO DIPARTIMENTO DI INGEGNERIA DELL'INFORMAZIONE
DISIT DISTRIBUTED SYSTEMS AND INTERNET TECHNOLOGIES LAB

DISIT LOG: Data Properties & Values of a Resource

https://log.disit.org/service/index.php?uri=**http://www.disit.org/km4city/resource/OS00023122303RE/34**&sparql=http://192.168.0.208:8890/sparql

1. Right-click on 

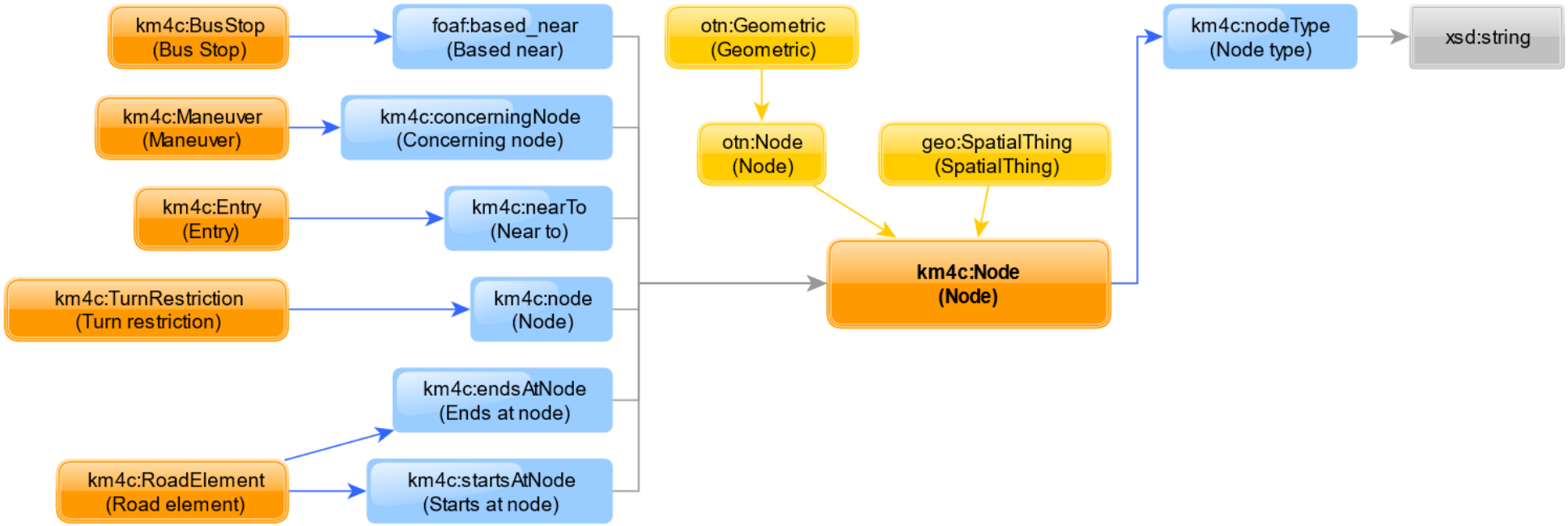
2. And hit **Info** 

SPARQL Query: Values of Data Properties (of a given Resource)

```
select ?p ?v {
    <http://www.disit.org/km4city/resource/OS00023122303RE/34> ?p ?v .
    filter(isLiteral(?v))
}
```

p	v
http://purl.org/dc/terms/identifier	"OS00023122303RE/34"
http://www.disit.org/km4city/schema#highwayType	"trunk"
http://www.disit.org/km4city/schema#composition	"carreggiate separate"
http://www.disit.org/km4city/schema#elemLocation	"a raso"
http://www.disit.org/km4city/schema#elementClass	"extraurbana principale"
http://www.disit.org/km4city/schema#elementType	"di tronco carreggiata"
http://www.disit.org/km4city/schema#length	"135.0e0"
http://www.disit.org/km4city/schema#operatingStatus	"in esercizio"
http://www.disit.org/km4city/schema#speedLimit	"90"
http://www.disit.org/km4city/schema#trafficDir	"tratto stradale aperto nella direzione positiva (da giunzione NOD_INI a giunzione NOD_FIN)"
http://www.disit.org/km4city/schema#width	"non rilevato"
http://www.disit.org/km4city/schema#route	"LINESTRING(10.8591408 45.4809736,10.8592019 45.4797626)"^^<http://www.openlinksw.com/schemas/virtrdf#Geometry>

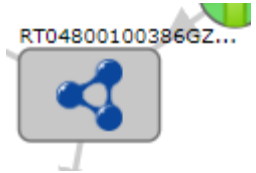
Km4City Ontology: Node



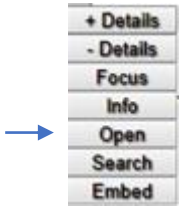
DISIT LOG: Exploit Linked Data

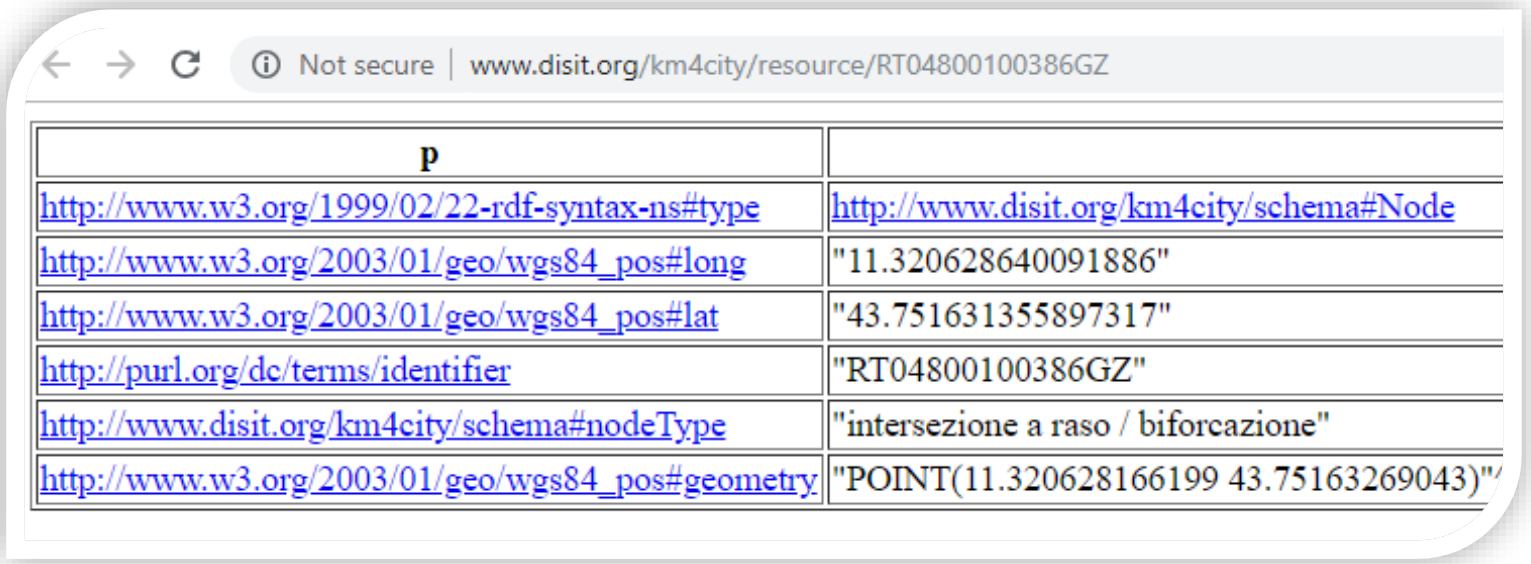
https://log.disit.org/service/index.php?uri=**http://www.disit.org/km4city/resource/RT04800100386GZ**&sparql=http://192.168.0.206:8890/sparql

1. Right-click on



2. And hit **Open**





p	
http://www.w3.org/1999/02/22-rdf-syntax-ns#type	http://www.disit.org/km4city/schema#Node
http://www.w3.org/2003/01/geo/wgs84_pos#long	"11.320628640091886"
http://www.w3.org/2003/01/geo/wgs84_pos#lat	"43.751631355897317"
http://purl.org/dc/terms/identifier	"RT04800100386GZ"
http://www.disit.org/km4city/schema#nodeType	"intersezione a raso / biforcazione"
http://www.w3.org/2003/01/geo/wgs84_pos#geometry	"POINT(11.320628166199 43.75163269043)"

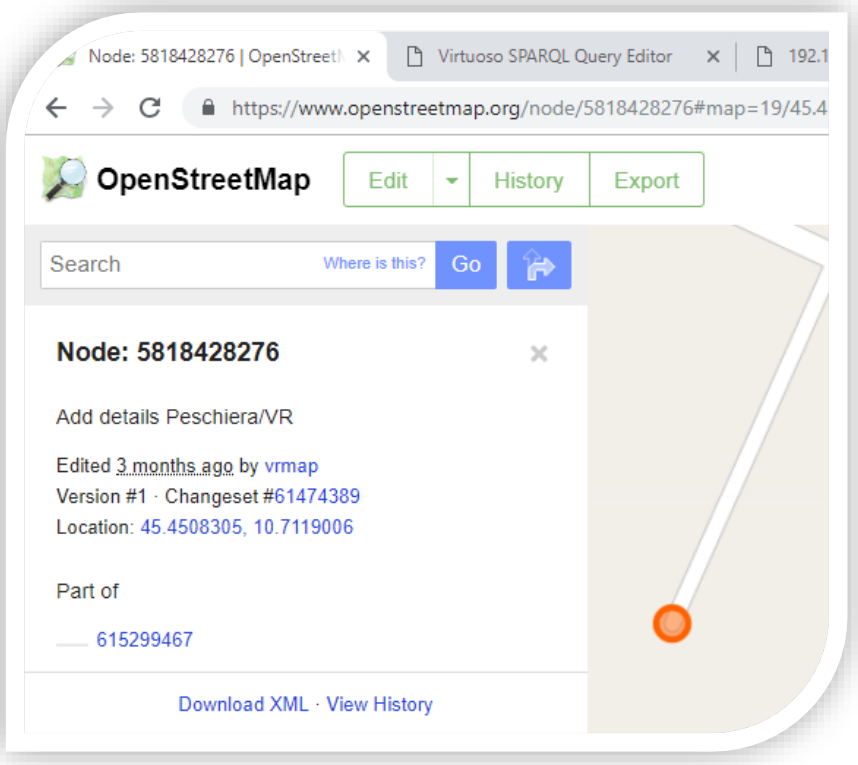
Node *Resource*: Km4City KB vs OSM

Km4City KB

- `select * { <http://www.disit.org/km4city/resource/OS0`**`5818428276`**`NO> ?p ?v }`
- http://192.168.0.208:8890/sparql?default-graph-uri=&query=select+*+%7B+%3Chttp%3A%2F%2Fwww.disit.org%2Fkm4city%2Fresource%2FOS05818428276NO%3E+%3Fp+%3Fv+%7D&format=text%2Fhtml&timeout=0&debug=on

p	
http://www.w3.org/1999/02/22-rdf-syntax-ns#type	http://www.disit.org/km4city/schema#Node
http://purl.org/dc/terms/identifier	"OS05818428276NO"
http://www.w3.org/2003/01/geo/wgs84_pos#lat	45.4508
http://www.w3.org/2003/01/geo/wgs84_pos#long	10.7119
http://www.disit.org/km4city/schema#nodeType	"terminale (inizio o fine elemento stradale)"
http://www.w3.org/2003/01/geo/wgs84_pos#geometry	"POINT(10.71190071106 45.450832366943)"

Open Street Map



Node *Resource*: Km4City KB vs OSM

Km4City KB

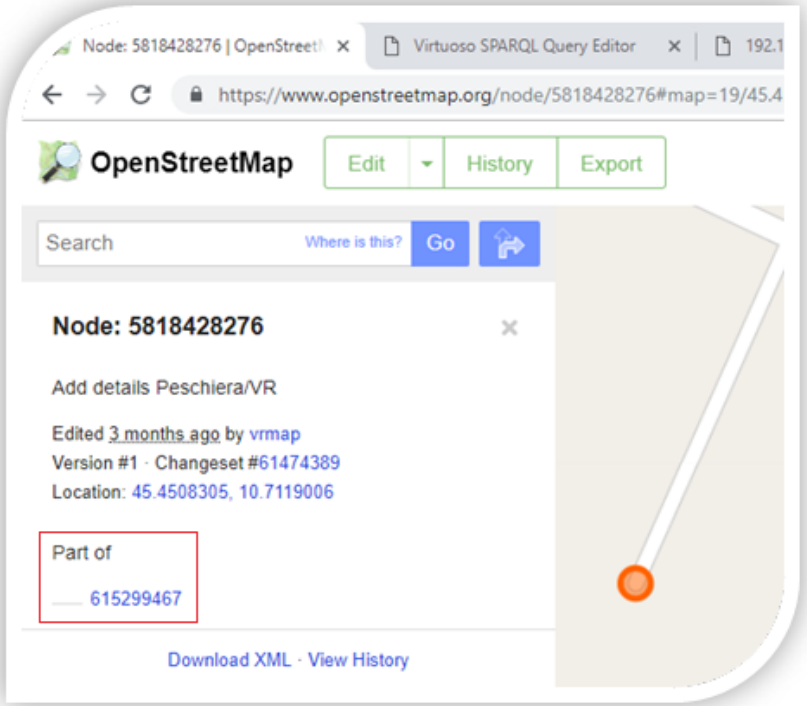
- ```
  select * {
  ?re a km4c:RoadElement;
  km4c:startsAtNode
  <http://www.disit.org/km4city/resource/OS05818428276NO> }
  ```

re
http://www.disit.org/km4city/resource/OS00615299467RE/0

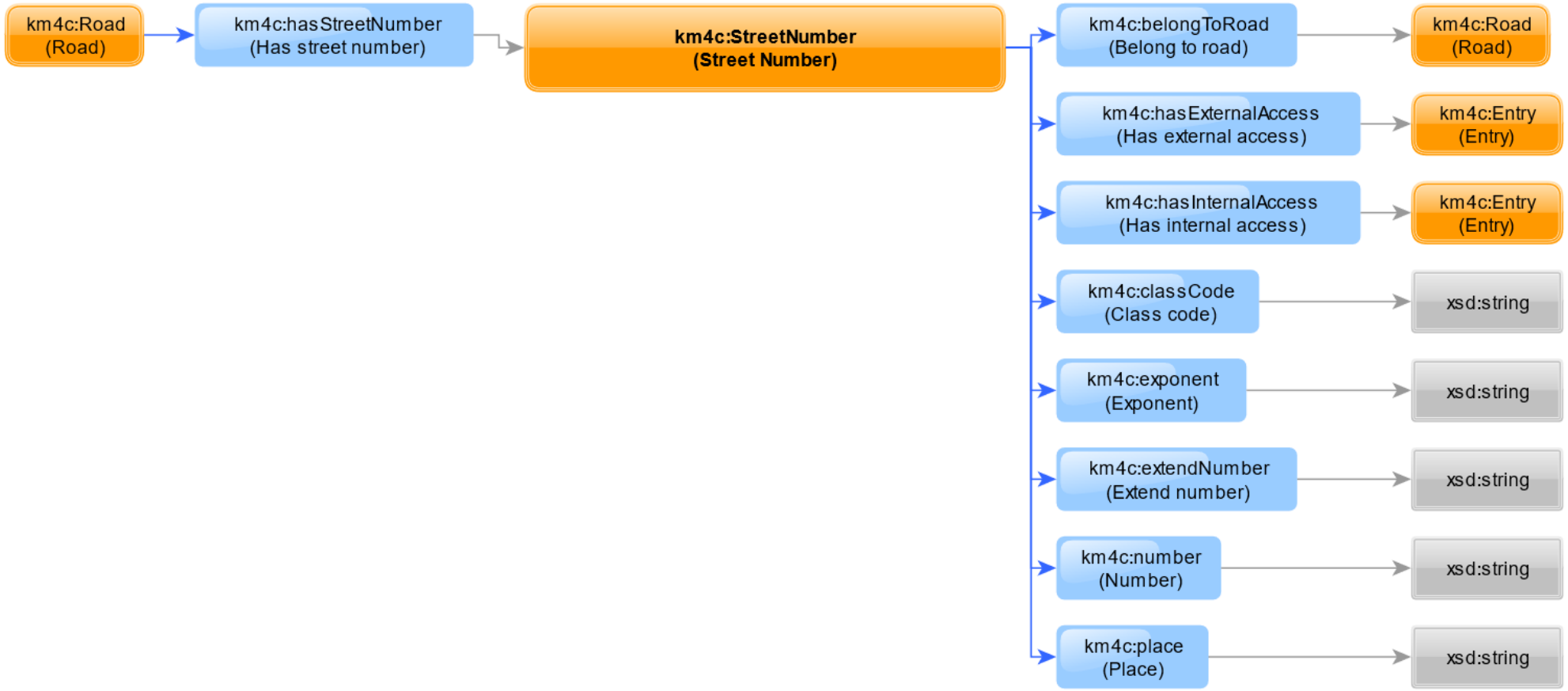
- ```
  select * { ?r a km4c:Road;
  km4c:containsElement
  <http://www.disit.org/km4city/resource/OS00615299467RE/0> }
  ```

r
http://www.disit.org/km4city/resource/OS00615299467SR

Open Street Map



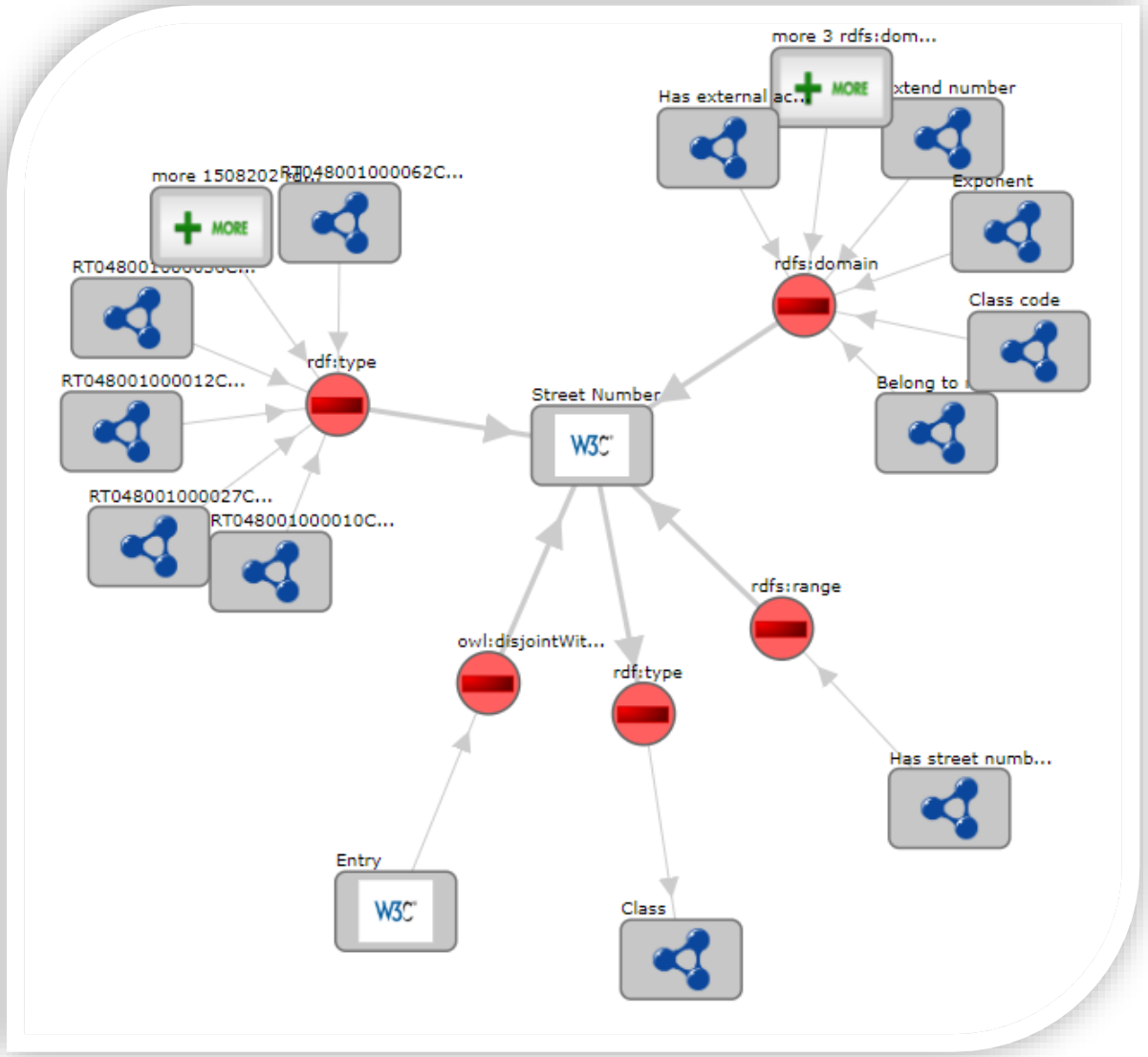
Km4City Ontology: StreetNumber



DISIT LOG: Explore Relations among *Classes*

https://log.disit.org/service/index.php?uri=**http://www.disit.org/km4city/schema%23StreetNumber**&sparql=http://192.168.0.206:8890/sparql

- If you submit the URI of a Class instead of the URI of a Resource, the LOD will display you (and will allow you to browse through) the set of the incoming and outgoing relations of the given Class with other Classes *and Resources.*



SPARQL Query: Explore Relations Among Classes

```
select distinct ?class ?property {
    ?class ?property <http://www.disit.org/km4city/schema#StreetNumber> .
    ?class a owl:Class .
}
```

class	property
http://www.disit.org/km4city/schema#Entry	http://www.w3.org/2002/07/owl#disjointWith

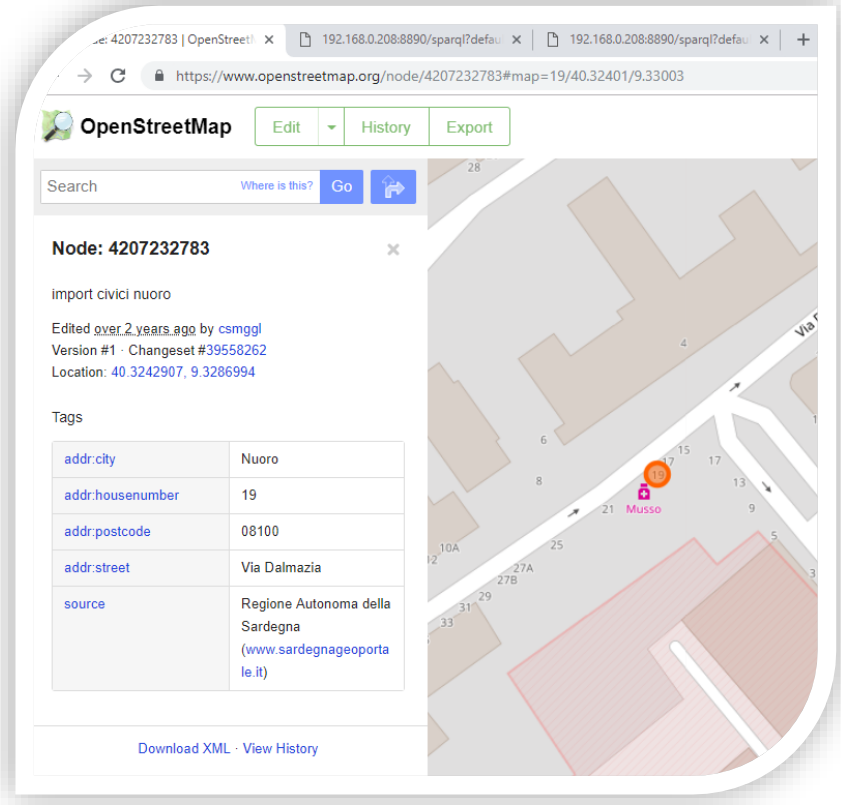
Street Number *Resource*: Km4City KB vs OSM

Km4City KB

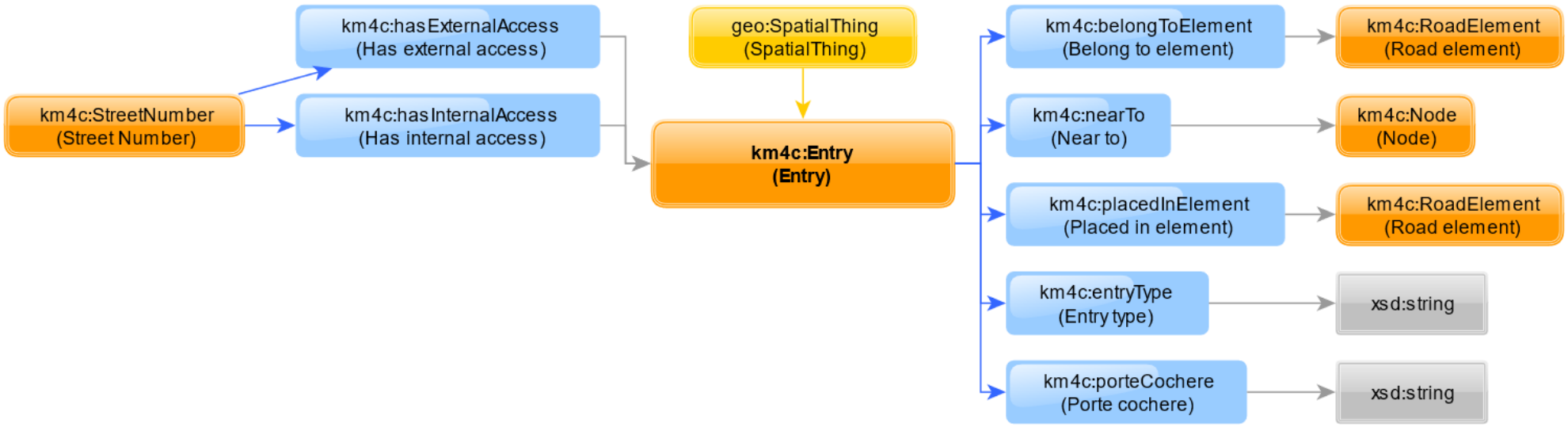
```
select distinct ?rn ?n {
<http://www.disit.org/km4city/resource/OS0420723278 3NN>
km4c:extendNumber ?n ;
km4c:belongToRoad ?r .
?r km4c:extendName ?rn
}
```

rn	n
"Via Dalmazia"	"19"

Open Street Map



Km4City Ontology: Entry



DISIT LOG: Explore *Class* Metadata

https://log.disit.org/service/index.php?uri=**http://www.disit.org/km4city/schema%23Entry**&sparql=http://192.168.0.206:8890/sparql

- If you submit the URI of a Class instead of the URI of a Resource, you right-click the Class icon and you hit **Info**, you will get the full listing of the metadata that are available for the given *Class.*

SPARQL Query: Explore Class Metadata

```
SELECT ?subject ?property ?object WHERE {{
<http://www.disit.org/km4city/schema#Entry> ?property ?object } UNION {
?subject ?property <http://www.disit.org/km4city/schema#Entry> } }
```

subject	property	object
	http://www.w3.org/1999/02/22-rdf-syntax-ns#type	http://www.w3.org/2002/07/owl#Class
	http://www.w3.org/2000/01/rdf-schema#label	"Accesso"@it
	http://www.w3.org/2000/01/rdf-schema#label	"Entry"@en
	http://www.w3.org/2000/01/rdf-schema#comment	"Classe le cui istanze sono i possibili ingressi ai numeri civici"
	http://www.w3.org/2002/07/owl#disjointWith	http://www.disit.org/km4city/schema#StreetNumber
	http://www.w3.org/2000/01/rdf-schema#subClassOf	http://www.w3.org/2003/01/geo/wgs84_pos#SpatialThing
	http://www.w3.org/2000/01/rdf-schema#subClassOf	nodeID://b26305
	http://www.w3.org/2000/01/rdf-schema#subClassOf	nodeID://b26306
http://www.disit.org/km4city/resource/RT048044005674AC	http://www.w3.org/1999/02/22-rdf-syntax-ns#type	
http://www.disit.org/km4city/resource/RT048001000011AC	http://www.w3.org/1999/02/22-rdf-syntax-ns#type	
http://www.disit.org/km4city/resource/RT048001000034AC	http://www.w3.org/1999/02/22-rdf-syntax-ns#type	
http://www.disit.org/km4city/resource/RT048001000042AC	http://www.w3.org/1999/02/22-rdf-syntax-ns#type	
http://www.disit.org/km4city/resource/RT048001000082AC	http://www.w3.org/1999/02/22-rdf-syntax-ns#type	
http://www.disit.org/km4city/resource/RT048001000082AC	http://www.w3.org/1999/02/22-rdf-syntax-ns#type	
http://www.disit.org/km4city/resource/RT048001000142AC	http://www.w3.org/1999/02/22-rdf-syntax-ns#type	
http://www.disit.org/km4city/resource/RT048001000148AC	http://www.w3.org/1999/02/22-rdf-syntax-ns#type	

Entry *Resource*: Km4City KB vs OSM

Km4City KB

```
select distinct * {
<http://www.disit.org/km4city/resource/OS04207232783NN>
km4c:hasExternalAccess ?entry .
?entry ?p ?v
}
```

Open Street Map

Node: 4207232783

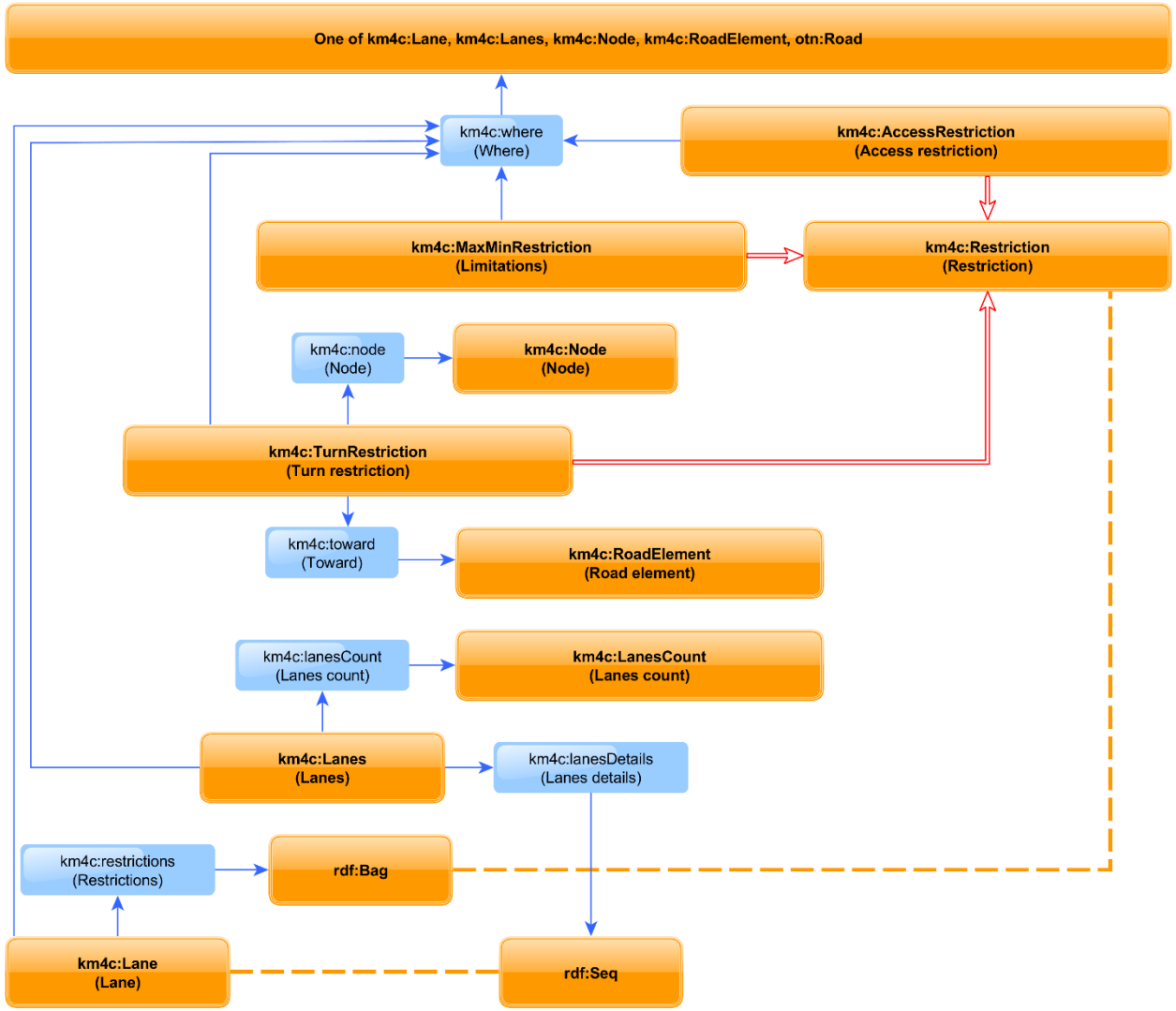
import civici nuoro

Edited over 2 years ago by csmggl
Version #1 · Changeset #39558262
Location: 40.3242907, 9.3286994

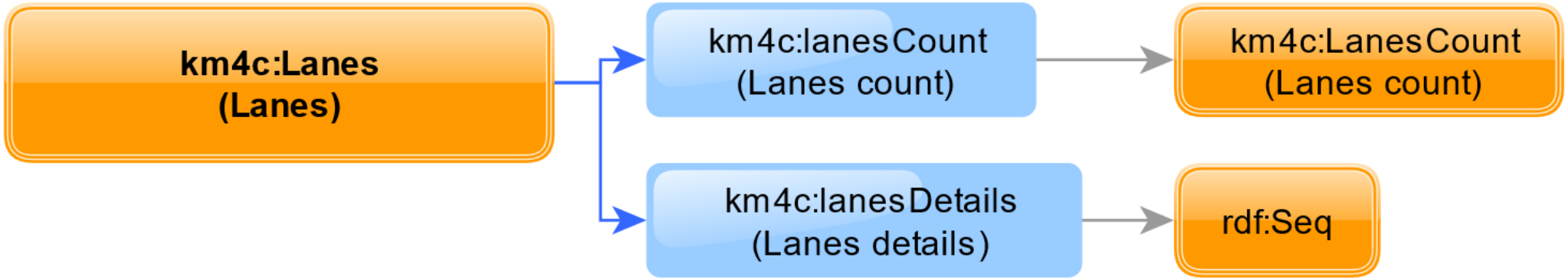
entry	p	v
http://www.disit.org/km4city/resource/OS04207232783NE	http://www.w3.org/1999/02/22-rdf-syntax-ns#type	http://www.disit.org/km4city/schema#Entry
http://www.disit.org/km4city/resource/OS04207232783NE	http://purl.org/dc/terms/identifier	"OS04207232783NE"
http://www.disit.org/km4city/resource/OS04207232783NE	http://www.w3.org/2003/01/geo/wgs84_pos#lat	40.3243
http://www.disit.org/km4city/resource/OS04207232783NE	http://www.w3.org/2003/01/geo/wgs84_pos#long	9.3287
http://www.disit.org/km4city/resource/OS04207232783NE	http://www.disit.org/km4city/schema#entryType	"Accesso esterno diretto"
http://www.disit.org/km4city/resource/OS04207232783NE	http://www.disit.org/km4city/schema#placedInElement	http://www.disit.org/km4city/resource/OS00027381231RE/12
http://www.disit.org/km4city/resource/OS04207232783NE	http://www.disit.org/km4city/schema#porteCochere	"Accesso non carrabile"
http://www.disit.org/km4city/resource/OS04207232783NE	http://www.w3.org/2003/01/geo/wgs84_pos#geometry	"POINT(9.3286991119385 40.324291229248)"^^<http://www.openlinksw.com/schemas/virtrdf#Geometry>

Km4City Ontology: Street Graph (v1.6.5)

- Lanes
  - LanesCount
  - Lane
- Restriction
  - AccessRestrictions
  - TurnRestrictions
  - MaxMinRestrictions
- A Lane *can* have a ***Bag*** of Restriction
- A Lanes res. Can have a **Seq** of Lane



Km4City Ontology: Lanes

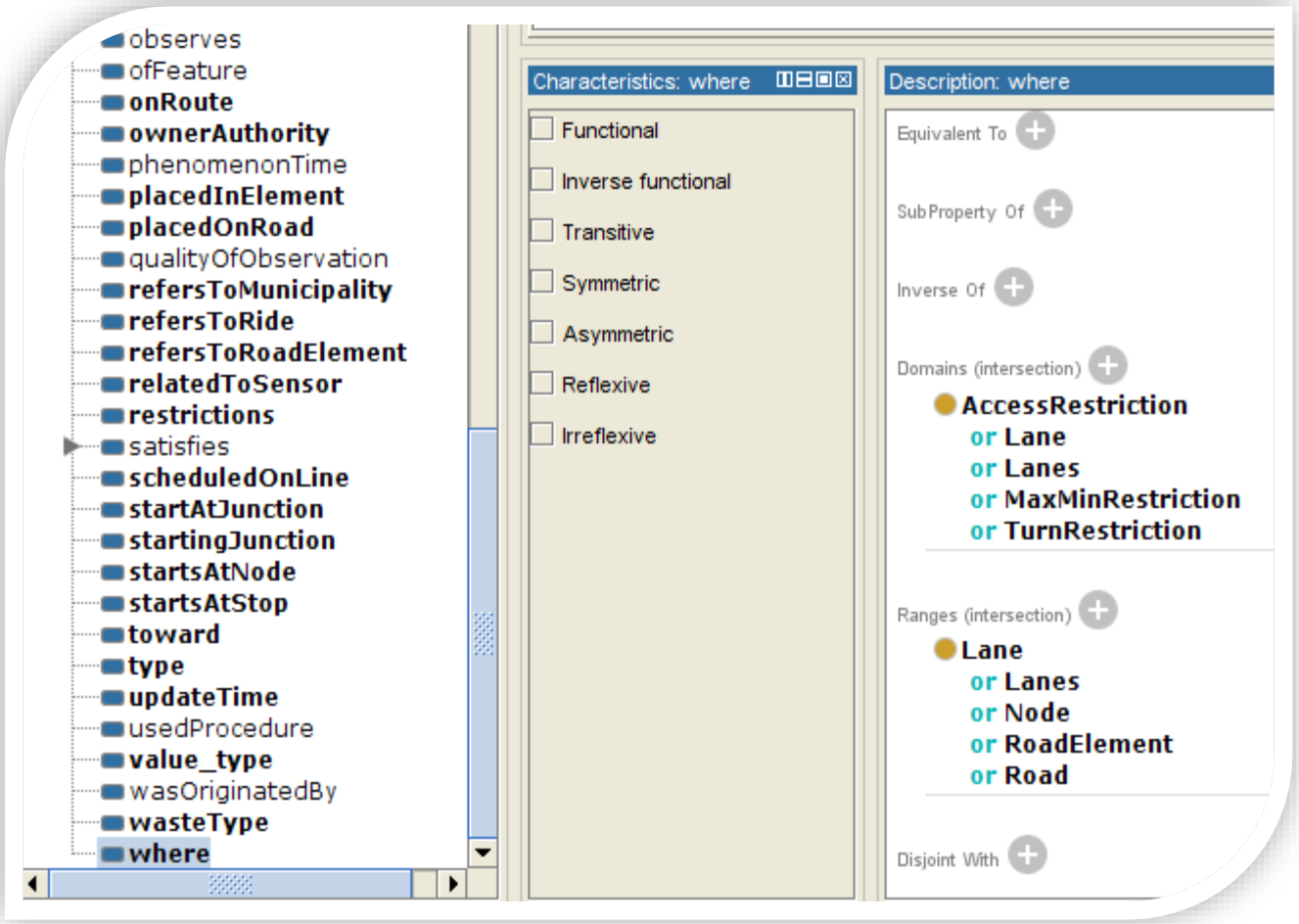


World is not perfect: Where are Lanes?

- The WLODE needs to be improved for this aspect, since it appears not to be able to render properly domains and ranges that result from union/intersection

- The km4c:where object property *can* be found in resources of type Lane, but it also can be found on resources of type Lanes, …

- World is not perfect: the where property has a different semantic in resources of type Lane (where it has to be interpreted as «it is a part of») with respect to resources of type Lanes, and Restriction

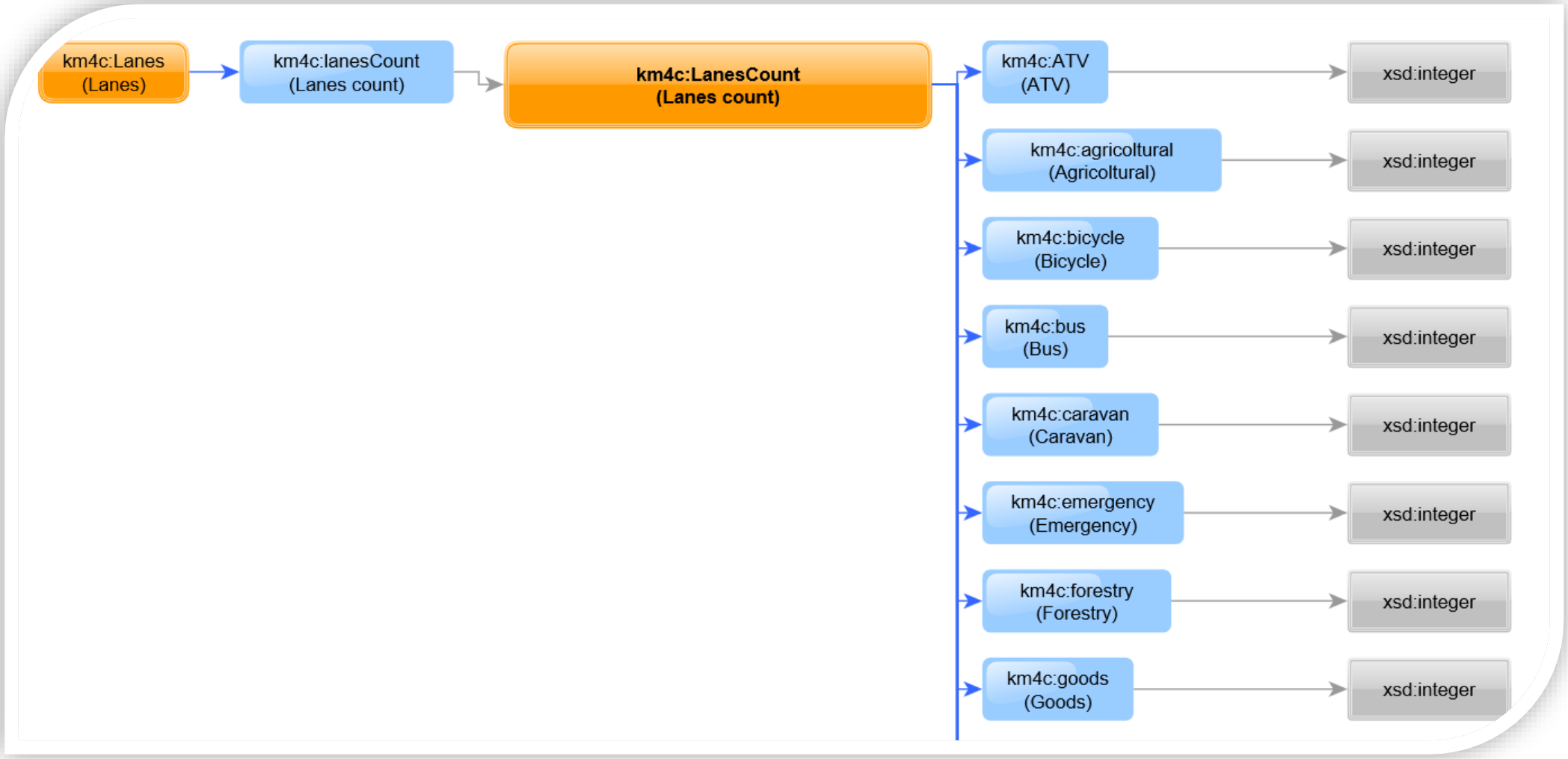


SPARQL Query: Lanes

```
select * { ?ls a km4c:Lanes; ?lsp ?lsv } order by ?ls ?lsp
```

ls	lsp	lsv
http://www.disit.org/km4city/resource/OS000000031192LR/lanes/alldirections	http://www.disit.org/km4city/schema#lanesCount	http://www.disit.org/km4city/resource/OS000000031192LR/lanes/alldirections/count
http://www.disit.org/km4city/resource/OS000000031192LR/lanes/alldirections	http://www.disit.org/km4city/schema#where	http://www.disit.org/km4city/resource/OS000000031192LR
http://www.disit.org/km4city/resource/OS000000031192LR/lanes/alldirections	http://www.w3.org/1999/02/22-rdf-syntax-ns#type	http://www.disit.org/km4city/schema#Lanes
http://www.disit.org/km4city/resource/OS000002132537RE/0/lanes/alldirections	http://www.disit.org/km4city/schema#lanesCount	http://www.disit.org/km4city/resource/OS000002132537RE/0/lanes/alldirections/count
http://www.disit.org/km4city/resource/OS000002132537RE/0/lanes/alldirections	http://www.disit.org/km4city/schema#where	http://www.disit.org/km4city/resource/OS000002132537RE/0
http://www.disit.org/km4city/resource/OS000002132537RE/0/lanes/alldirections	http://www.w3.org/1999/02/22-rdf-syntax-ns#type	http://www.disit.org/km4city/schema#Lanes
http://www.disit.org/km4city/resource/OS000002132537RE/1/lanes/alldirections	http://www.disit.org/km4city/schema#lanesCount	http://www.disit.org/km4city/resource/OS000002132537RE/1/lanes/alldirections/count
http://www.disit.org/km4city/resource/OS000002132537RE/1/lanes/alldirections	http://www.disit.org/km4city/schema#where	http://www.disit.org/km4city/resource/OS000002132537RE/1
http://www.disit.org/km4city/resource/OS000002132537RE/1/lanes/alldirections	http://www.w3.org/1999/02/22-rdf-syntax-ns#type	http://www.disit.org/km4city/schema#Lanes
http://www.disit.org/km4city/resource/OS000002132537RE/2/lanes/alldirections	http://www.disit.org/km4city/schema#lanesCount	http://www.disit.org/km4city/resource/OS000002132537RE/2/lanes/alldirections/count
http://www.disit.org/km4city/resource/OS000002132537RE/2/lanes/alldirections	http://www.disit.org/km4city/schema#where	http://www.disit.org/km4city/resource/OS000002132537RE/2
http://www.disit.org/km4city/resource/OS000002132537RE/2/lanes/alldirections	http://www.w3.org/1999/02/22-rdf-syntax-ns#type	http://www.disit.org/km4city/schema#Lanes
http://www.disit.org/km4city/resource/OS000002132546RE/0/lanes/alldirections	http://www.disit.org/km4city/schema#lanesCount	http://www.disit.org/km4city/resource/OS000002132546RE/0/lanes/alldirections/count
http://www.disit.org/km4city/resource/OS000002132546RE/0/lanes/alldirections	http://www.disit.org/km4city/schema#where	http://www.disit.org/km4city/resource/OS000002132546RE/0
http://www.disit.org/km4city/resource/OS000002132546RE/0/lanes/alldirections	http://www.w3.org/1999/02/22-rdf-syntax-ns#type	http://www.disit.org/km4city/schema#Lanes
http://www.disit.org/km4city/resource/OS000002132546RE/1/lanes/alldirections	http://www.disit.org/km4city/schema#lanesCount	http://www.disit.org/km4city/resource/OS000002132546RE/1/lanes/alldirections/count
http://www.disit.org/km4city/resource/OS000002132546RE/1/lanes/alldirections	http://www.disit.org/km4city/schema#where	http://www.disit.org/km4city/resource/OS000002132546RE/1

Km4City Ontology: LanesCount



SPARQL Query: LanesCount (the simple case)

```
select * { <http://www.disit.org/km4city/resource/OS00000031192LR> km4c:lanes ?v }
```

v
http://www.disit.org/km4city/resource/OS00000031192LR/lanes/alldirections

```
select * { <http://www.disit.org/km4city/resource/OS00000031192LR/lanes/alldirections> ?p ?v }
```

p	v
http://www.w3.org/1999/02/22-rdf-syntax-ns#type	http://www.disit.org/km4city/schema#Lanes
http://www.disit.org/km4city/schema#lanesCount	http://www.disit.org/km4city/resource/OS00000031192LR/lanes/alldirections/count
http://www.disit.org/km4city/schema#where	http://www.disit.org/km4city/resource/OS00000031192LR

```
select * { <http://www.disit.org/km4city/resource/OS00000031192LR/lanes/alldirections/count>
?p ?v  }
```

p	v
http://www.w3.org/1999/02/22-rdf-syntax-ns#type	http://www.disit.org/km4city/schema#LanesCount
http://www.disit.org/km4city/schema#undesignated	2

SPARQL Query: LanesCount (the “complex” case)

```
select * { <http://www.disit.org/km4city/resource/OS00007997331SR> km4c:lanes ?v }
```

v
http://www.disit.org/km4city/resource/OS00007997331SR/lanes/alldirections
http://www.disit.org/km4city/resource/OS00007997331SR/lanes/backward
http://www.disit.org/km4city/resource/OS00007997331SR/lanes/forward

```
select * { <http://www.disit.org/km4city/resource/OS00007997331SR/lanes/forward> ?p ?v }
```

p	v
http://www.w3.org/1999/02/22-rdf-syntax-ns#type	http://www.disit.org/km4city/schema#Lanes
http://www.disit.org/km4city/schema#direction	"forward"
http://www.disit.org/km4city/schema#lanesCount	http://www.disit.org/km4city/resource/OS00007997331SR/lanes/forward/count
http://www.disit.org/km4city/schema#where	http://www.disit.org/km4city/resource/OS00007997331SR

```
select * { <http://www.disit.org/km4city/resource/OS00007997331SR/lanes/forward/count> ?p ?v }
```

p	v
http://www.w3.org/1999/02/22-rdf-syntax-ns#type	http://www.disit.org/km4city/schema#LanesCount
http://www.disit.org/km4city/schema#undesignated	"1"
http://www.disit.org/km4city/schema#bus	"1"

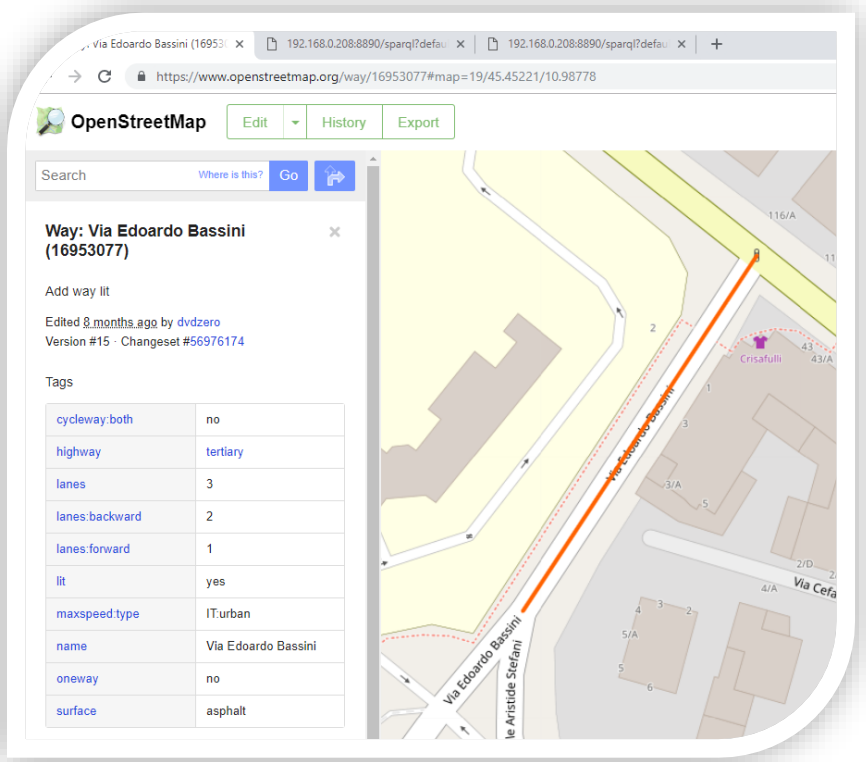
Lanes Count: Km4City KB vs OSM

Km4City KB

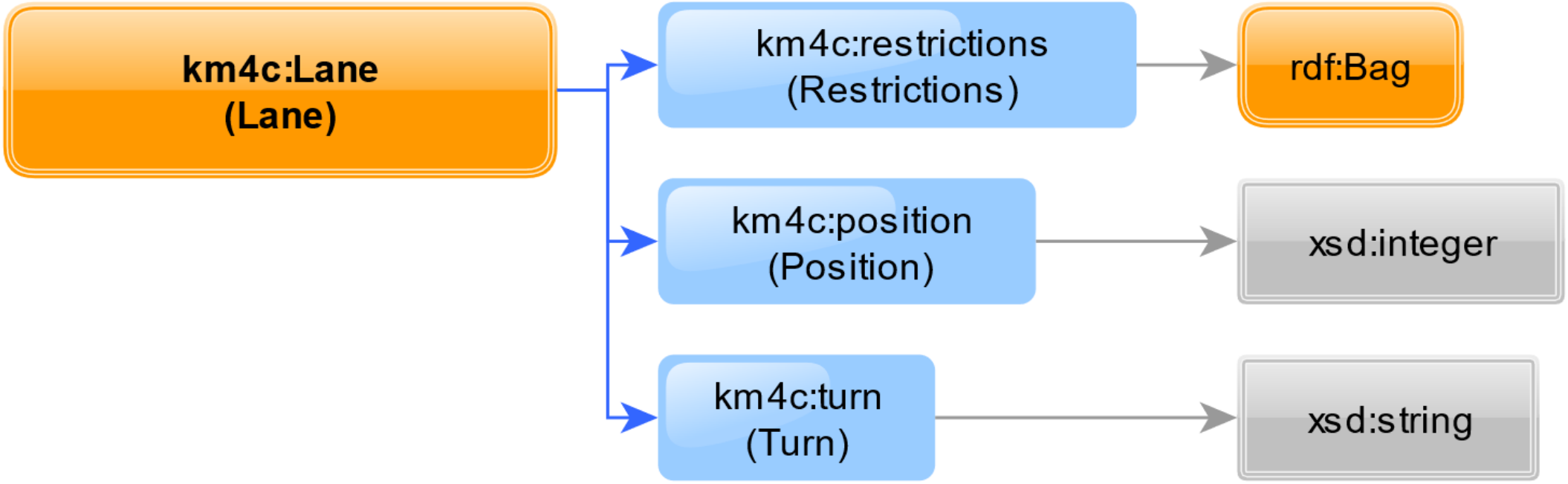
```
select ?lanescount ?v {
<http://www.disit.org/km4city/resource/OS00016953077SR> a km4c:Road;
km4c:lanes ?lanes .
?lanes km4c:lanesCount ?lanescount .
?lanescount km4c:undesignated ?v }
```

lanescount	v
http://www.disit.org/km4city/resource/OS00016953077SR/lanes/alldirections/count	3
http://www.disit.org/km4city/resource/OS00016953077SR/lanes/backward/count	2
http://www.disit.org/km4city/resource/OS00016953077SR/lanes/forward/count	1

Open Street Map



Km4City Ontology: Lane



SPARQL Query: Details about a given lane

```
select * {   <http://www.disit.org/km4city/resource/OS00036055473RE/0> ?p ?v }

select * {
  <http://www.disit.org/km4city/resource/OS00036055473RE/0/lanes/backward> ?p ?v
}

select * {
  <http://www.disit.org/km4city/resource/OS00036055473RE/0/lanes/backward/details> ?p ?v
}

select * {
  <http://www.disit.org/km4city/resource/OS00036055473RE/0/lanes/backward/2> ?p ?v
}
```

p	v
http://www.w3.org/1999/02/22-rdf-syntax-ns#type	http://www.disit.org/km4city/schema#Lane
http://www.disit.org/km4city/schema#where	http://www.disit.org/km4city/resource/OS00036055473RE/0/lanes/backward
http://www.disit.org/km4city/schema#position	"2"
http://www.disit.org/km4city/schema#turn	"merge_to_left"

Details about lanes: Km4City KB vs OSM

Km4City KB

- `select * {`
  `<http://www.disit.org/km4city/resource/OS00036055473RE/0> km4c:lanes ?lanes }`

lanes
http://www.disit.org/km4city/resource/OS00036055473RE/0/lanes/alldirections
http://www.disit.org/km4city/resource/OS00036055473RE/0/lanes/backward
http://www.disit.org/km4city/resource/OS00036055473RE/0/lanes/forward

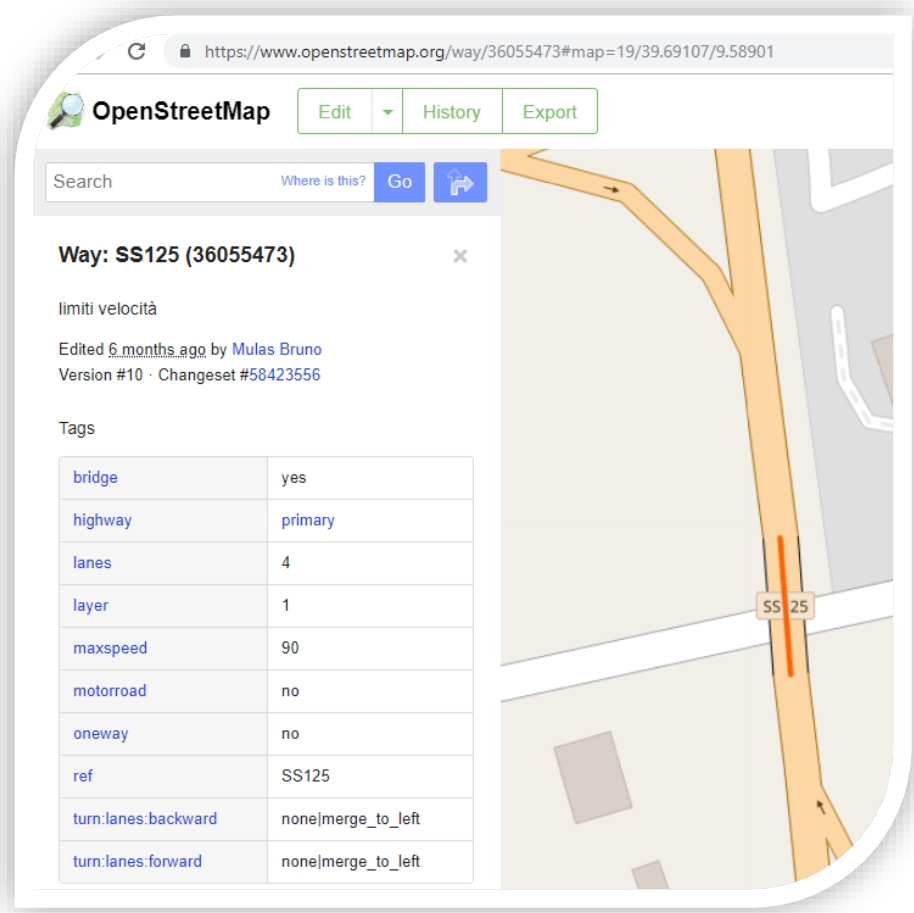
- `select ?p ?v {`
  `<http://www.disit.org/km4city/resource/OS00036055473RE/0/lanes/backward> km4c:lanesDetails ?list . ?list ?p ?v }`

p	v
http://www.w3.org/1999/02/22-rdf-syntax-ns#type	http://www.w3.org/1999/02/22-rdf-syntax-ns#Seq
http://www.w3.org/1999/02/22-rdf-syntax-ns#_1	http://www.disit.org/km4city/resource/OS00036055473RE/0/lanes/backward/1
http://www.w3.org/1999/02/22-rdf-syntax-ns#_2	http://www.disit.org/km4city/resource/OS00036055473RE/0/lanes/backward/2

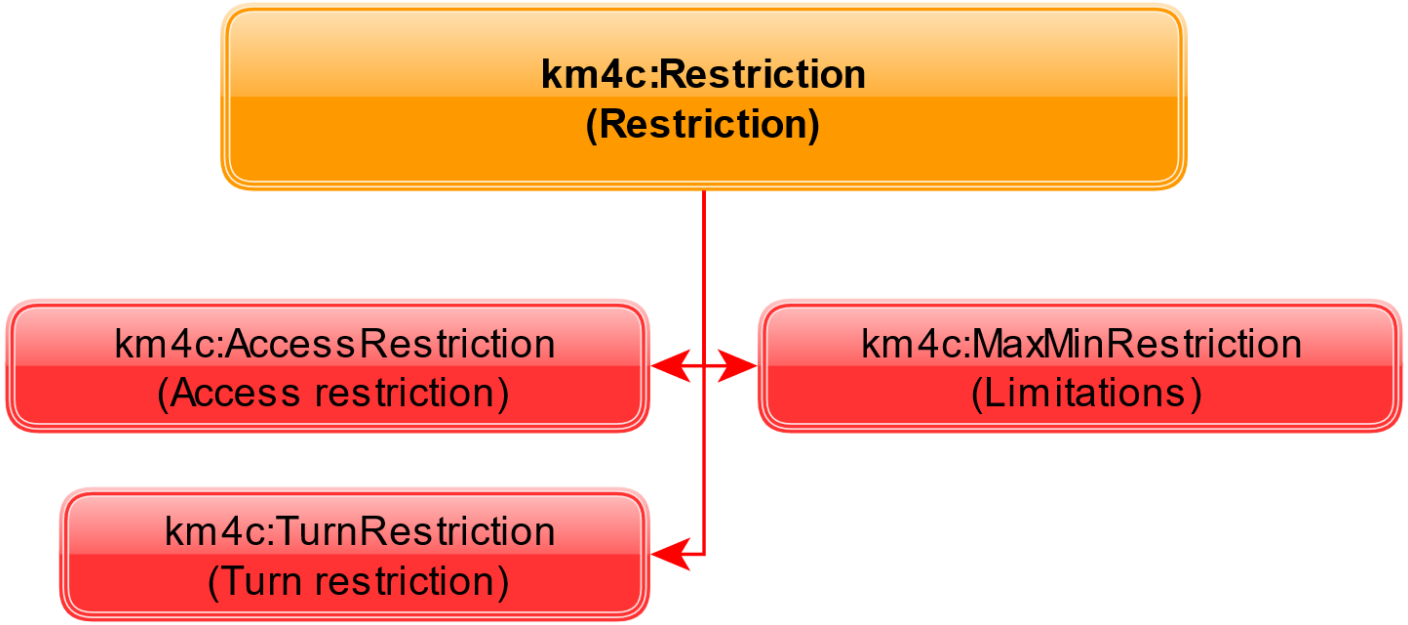
- `select * {`
  `<http://www.disit.org/km4city/resource/OS00036055473RE/0/lanes/backward/2> ?p ?v }`

p	v
http://www.w3.org/1999/02/22-rdf-syntax-ns#type	http://www.disit.org/km4city/schema#Lane
http://www.disit.org/km4city/schema#where	http://www.disit.org/km4city/resource/OS00036055473RE/0/lanes/backward
http://www.disit.org/km4city/schema#position	"2"
http://www.disit.org/km4city/schema#turn	"merge_to_left"

Open Street Map



Km4City Ontology: Restriction

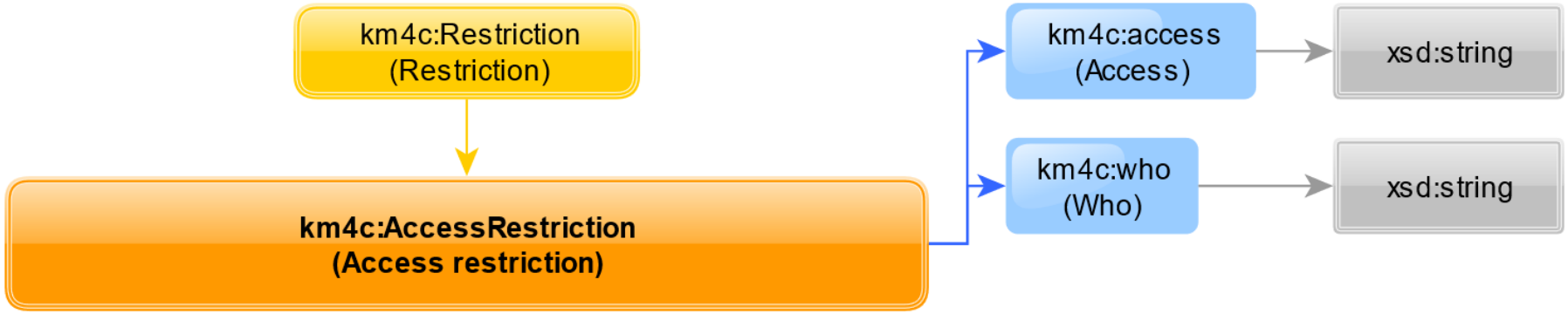


SPARQL Query: Discover restrictions on a road

```
select * {
    ?r a km4c:Restriction;
    km4c:where <http://www.disit.org/km4city/resource/OS00023116033SR>
}
```

ar
http://www.disit.org/km4city/resource/OS00023116033SR/restriction/access/hgv/alldirections/unconditioned

Km4City Ontology: AccessRestriction

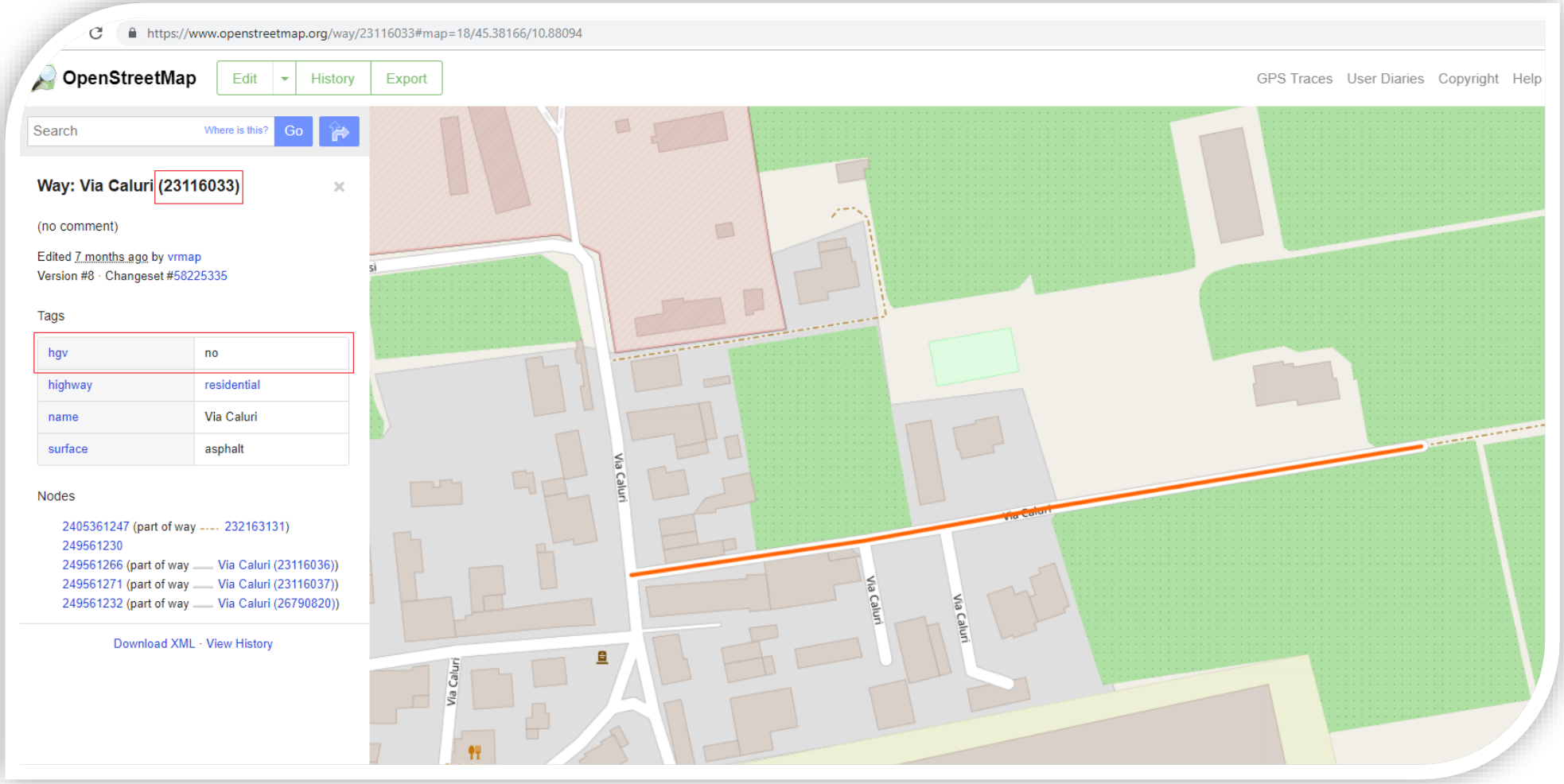


SPARQL Query: Access restriction (get details)

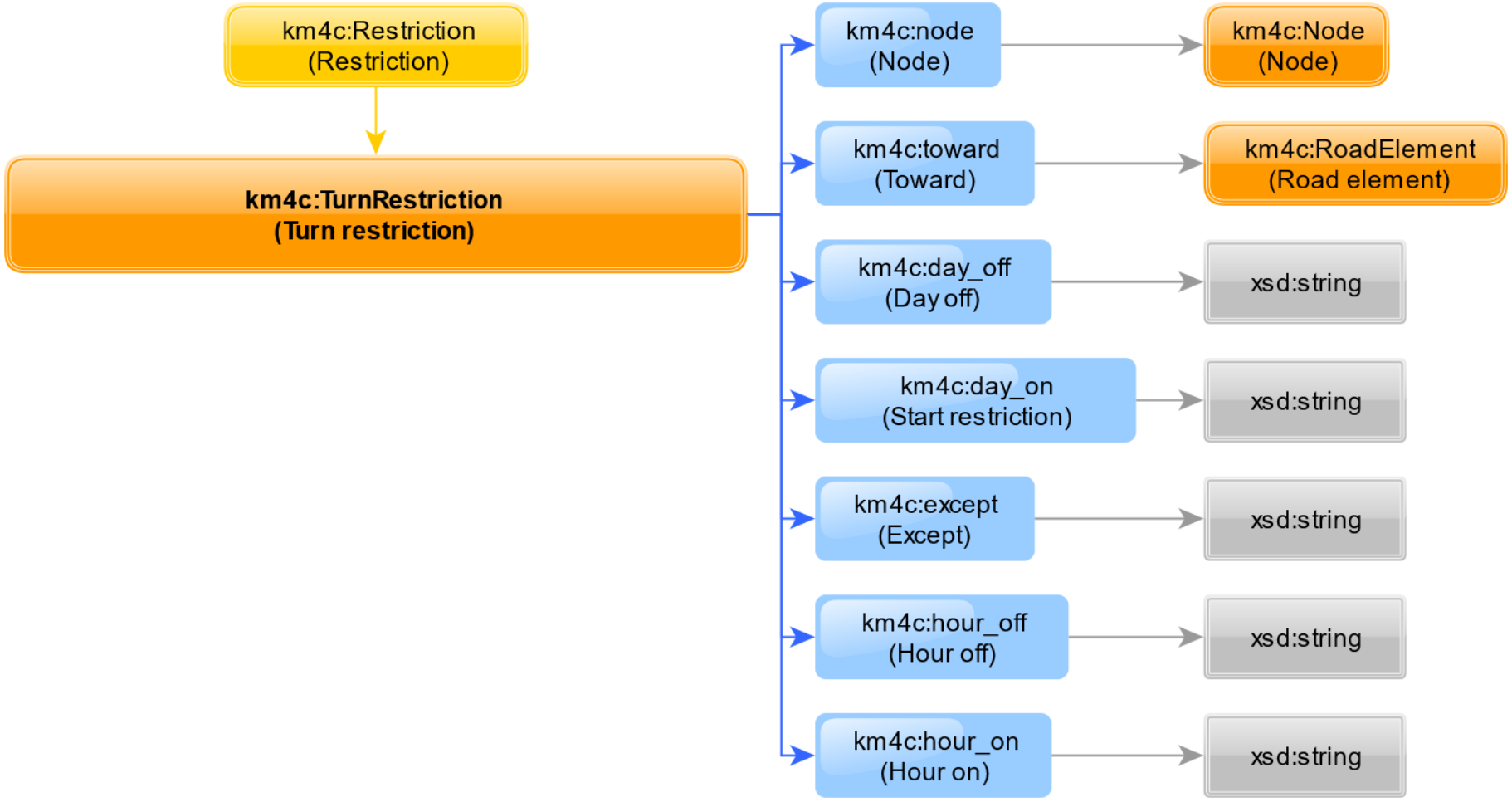
```
select * {
    <http://www.disit.org/km4city/resource/OS00023116033SR/restriction/access/hgv/alldirections/unconditioned> ?p ?v
}
```

p	v
http://www.w3.org/1999/02/22-rdf-syntax-ns#type	http://www.disit.org/km4city/schema#AccessRestriction
http://www.w3.org/1999/02/22-rdf-syntax-ns#type	http://www.disit.org/km4city/schema#Restriction
http://www.disit.org/km4city/schema#access	"no"
http://www.disit.org/km4city/schema#where	http://www.disit.org/km4city/resource/OS00023116033SR
http://www.disit.org/km4city/schema#who	"hgv"

Open Street Map: Access Restriction



Km4City Ontology: TurnRestriction

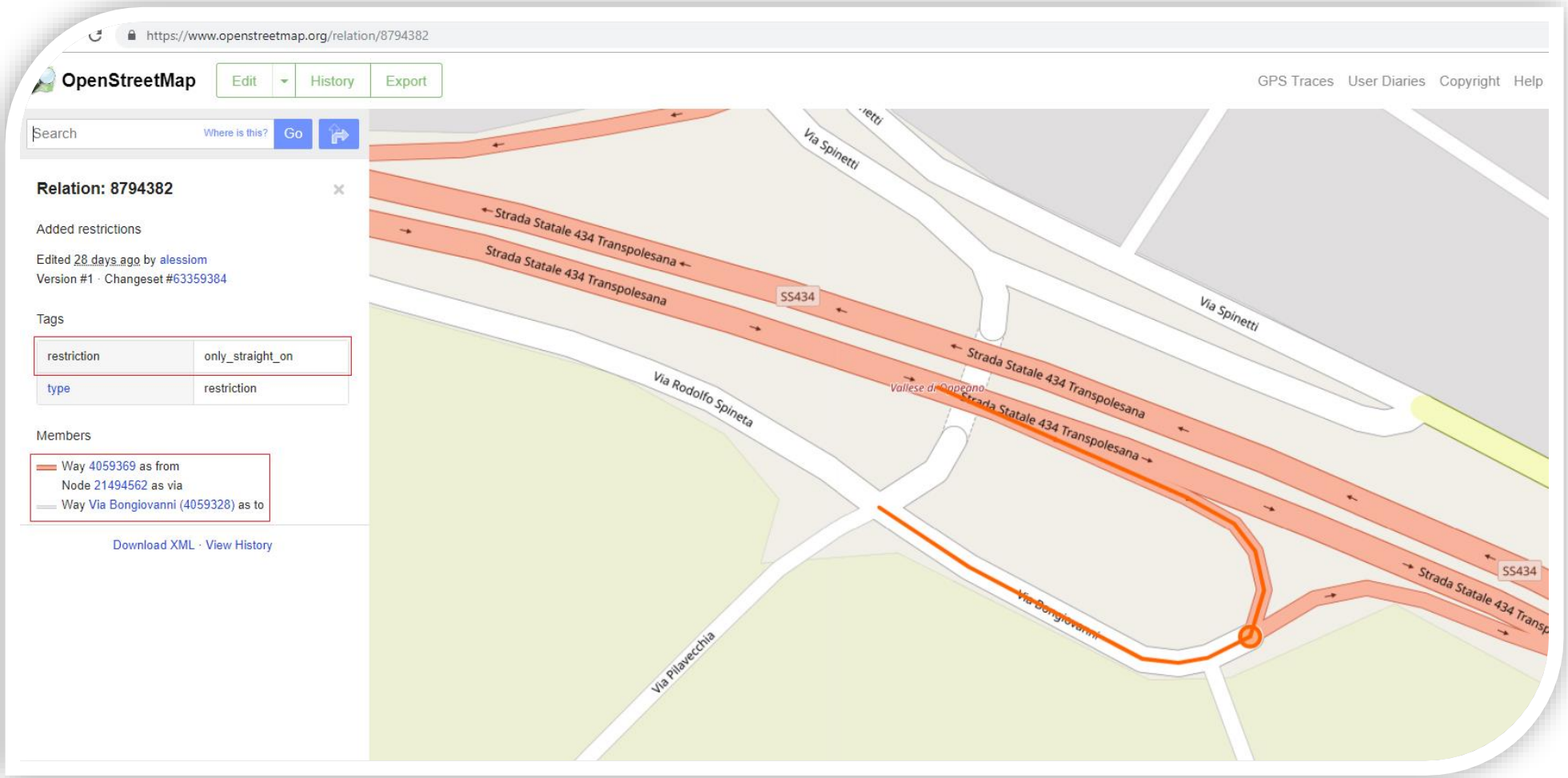


SPARQL Query: Turn restriction (get details)

```
select * { <http://www.disit.org/km4city/resource/OS00004059369RE/4/restriction/turn/OS00004059328RE/0> ?p ?v }
```

p	v
http://www.w3.org/1999/02/22-rdf-syntax-ns#type	http://www.disit.org/km4city/schema#Restriction
http://www.w3.org/1999/02/22-rdf-syntax-ns#type	http://www.disit.org/km4city/schema#TurnRestriction
http://www.disit.org/km4city/schema#node	http://www.disit.org/km4city/resource/OS00021494562NO
http://www.disit.org/km4city/schema#restriction	"only_straight_on"
http://www.disit.org/km4city/schema#toward	http://www.disit.org/km4city/resource/OS00004059328RE/0
http://www.disit.org/km4city/schema#where	http://www.disit.org/km4city/resource/OS00004059369RE/4

Open Street Map: Turn Restriction



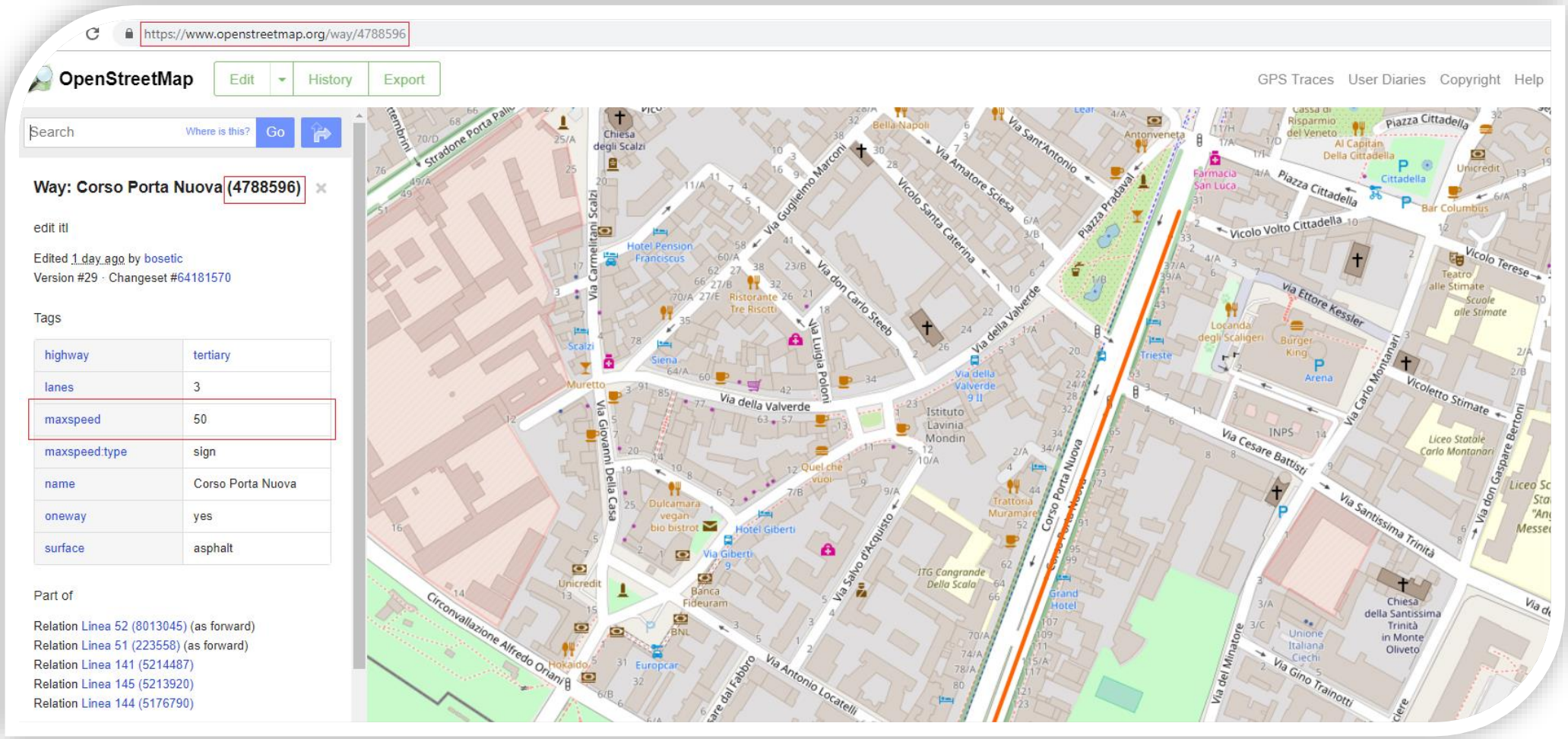
Km4City Ontology: MaxMinRestriction

SPARQL Query: Size/Weight/… restriction (details)

```
select * {
    <http://www.disit.org/km4city/resource/OS00004788596SR/restriction/maxmin/maxspeed/alldirections/unconditioned> ?p ?v
}
```

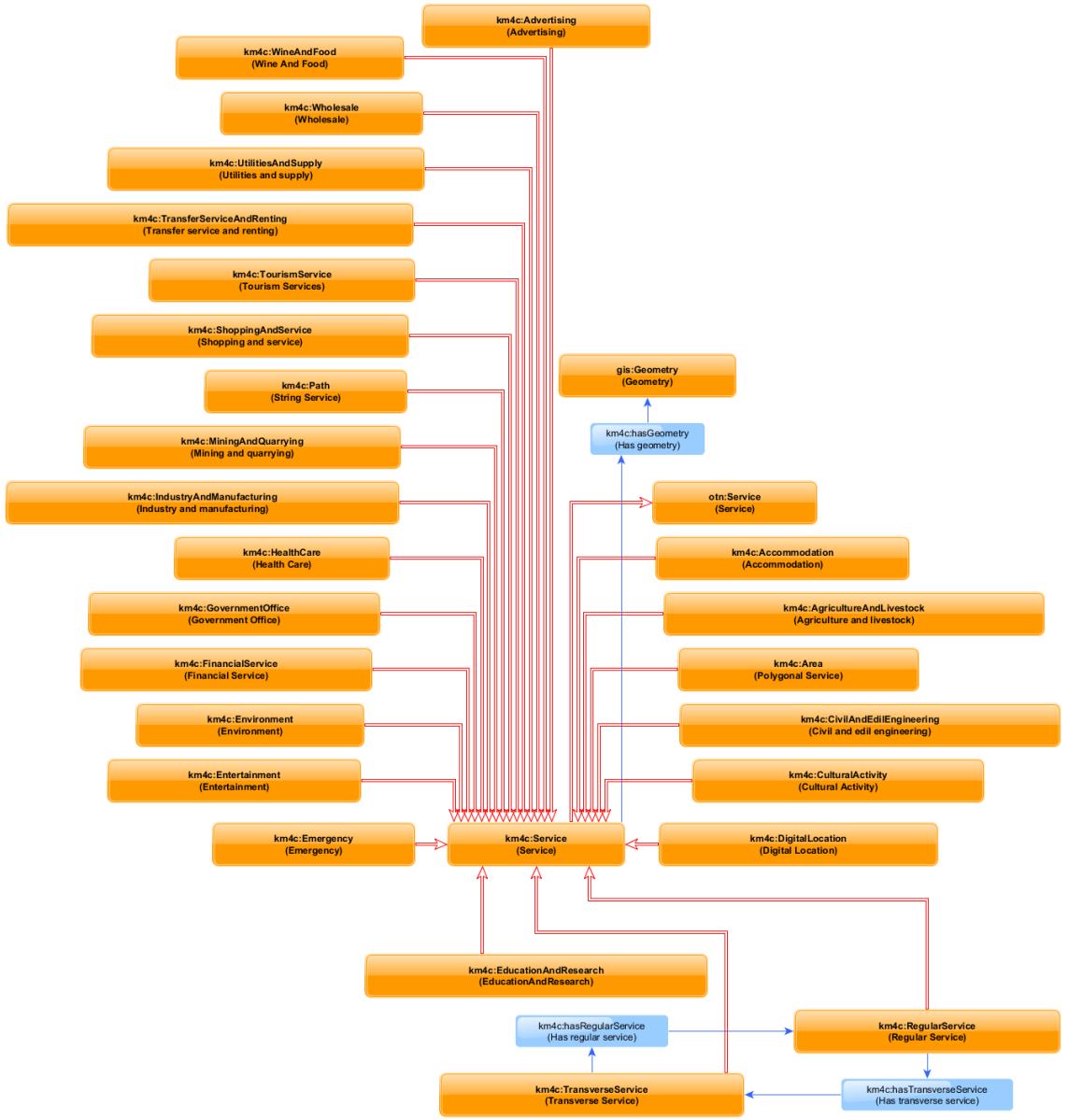
p	v
http://www.w3.org/1999/02/22-rdf-syntax-ns#type	http://www.disit.org/km4city/schema#MaxMinRestriction
http://www.w3.org/1999/02/22-rdf-syntax-ns#type	http://www.disit.org/km4city/schema#Restriction
http://www.disit.org/km4city/schema#limit	"50"
http://www.disit.org/km4city/schema#what	"maxspeed"
http://www.disit.org/km4city/schema#where	http://www.disit.org/km4city/resource/OS00004788596SR

Open Street Map: Speed limit



Km4City Ontology: Points Of Interest

- Service
  - RegularService
    - WineAndFood
    - Path
    - HealthCare
    - GovernmentOffice
    - Entertainment
    - Accommodation
    - …
  - TransverseService



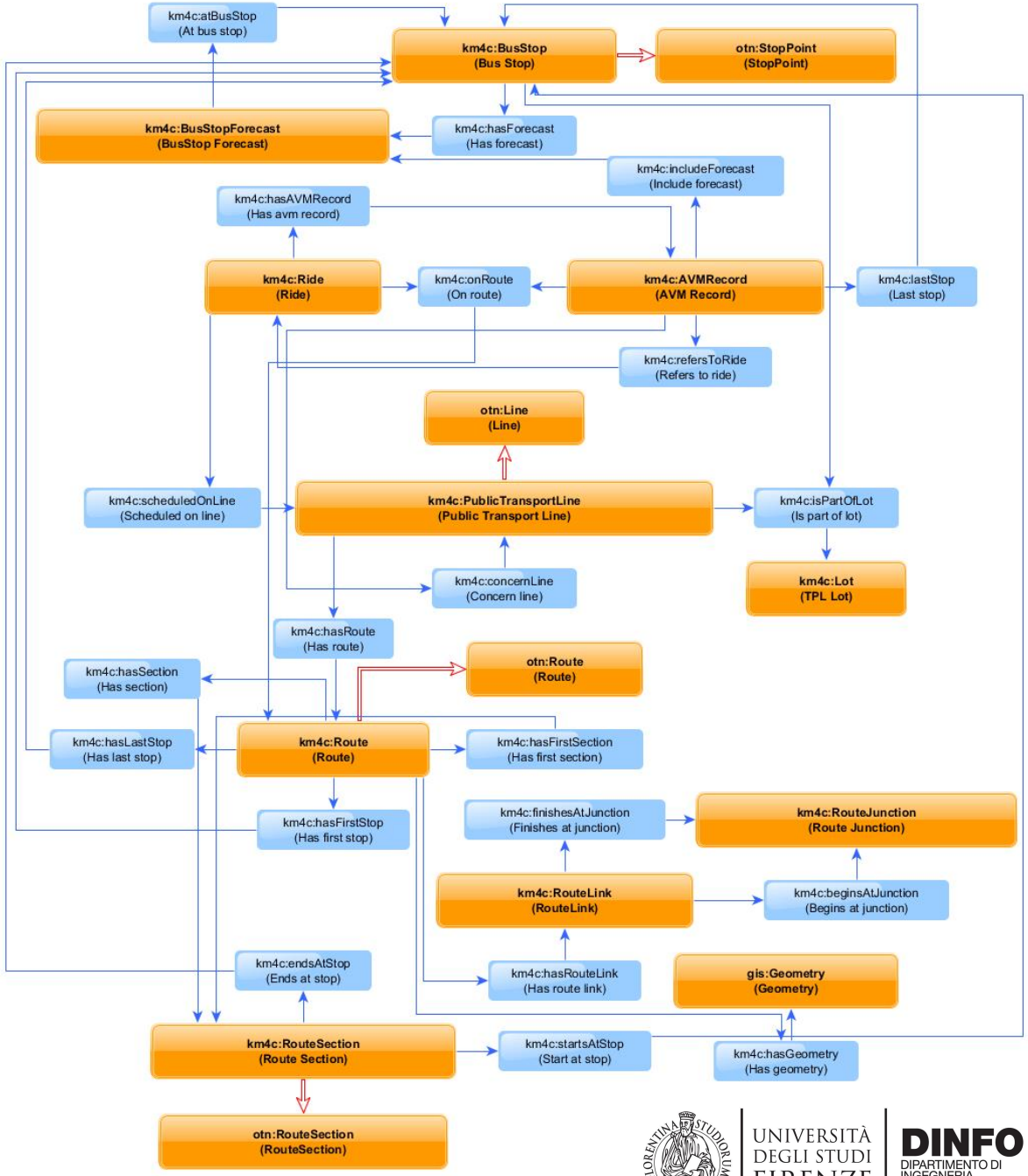
Km4City Ontology: Points of Interest

- Accomodation:
  - Holiday_village
  - Hotel
  - Summer_residence
  - Rest_home
  - Hostel
  - Farm_house
  - Beach_resort
  - Agritourism
  - Vacation_resort
  - Day_care_centre
  - Camping
  - Boarding_house
  - Mountain_shelter
  - Religiuos_guest_house
  - Bed_and_breakfast
  - Historic_residence
  - Summer_camp
  - Other_Accommodation
- ...

Category	Subcategories
Accommodation	18
FinancialService	10
Environment	12
MiningAndQuarrying	5
Advertising	2
Wholesale	10
CivilAndEdilEngineering	9
UtilitiesAndSupply	30
AgricultureAndLivestock	7
IndustryAndManufacturing	54
EducationAndResearch	33
Entertainment	27
Emergency	14
TourismService	15
HealthCare	25
WineAndFood	21
CulturalActivity	26
ShoppingAndService	140
GovernmentOffice	15
TransferServiceAndRenting	39

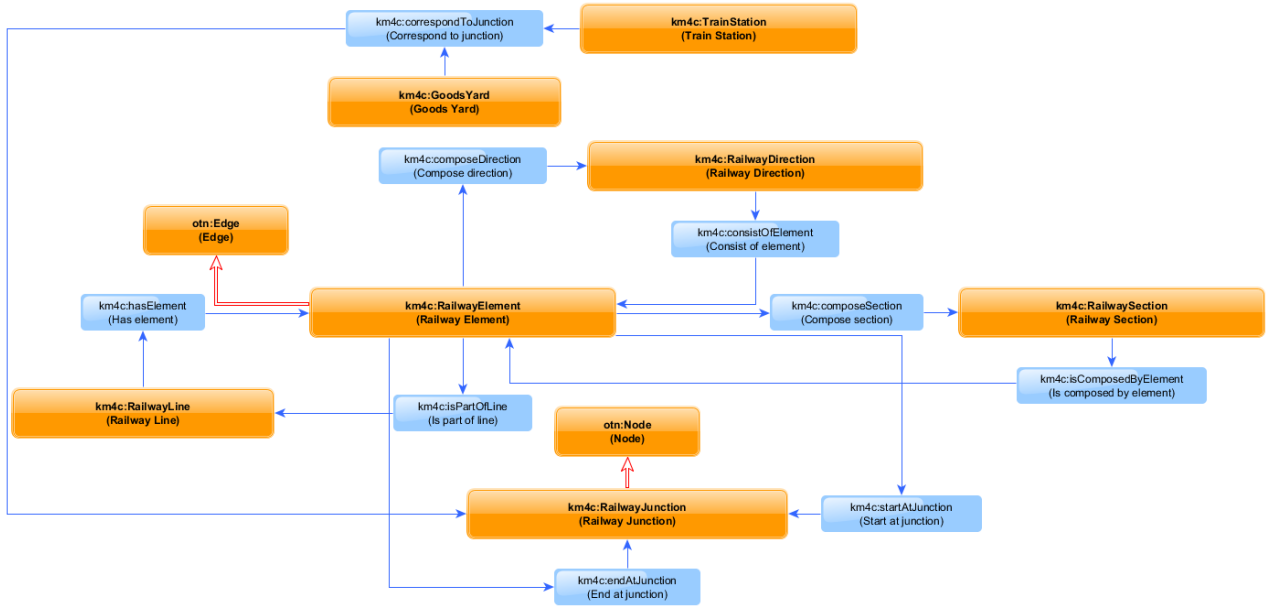
Km4City Ontology: Public Transport

- Lot
- PublicTransportLine
- Route
- RouteSection
- RouteLink
- RouteJunction
- Ride
- BusStop
- AVMRecord
- BusStopForecast
- Geometry



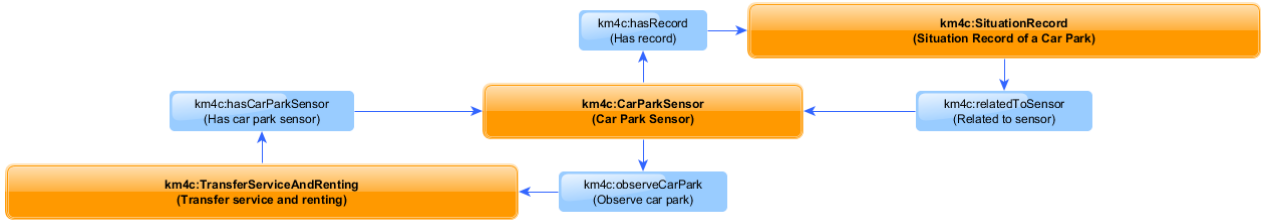
Km4City Ontology: Railways

- RailwayLine
- RailwaySection
- RailwayElement
- RailwayJunction
- TrainStation
- GoodsYard



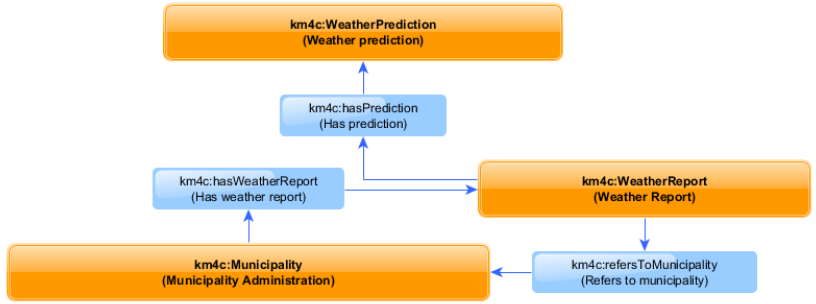
Km4City Ontology: Car Parks

- TransferServiceAndRenting
- CarParkSensor
- SituationRecord



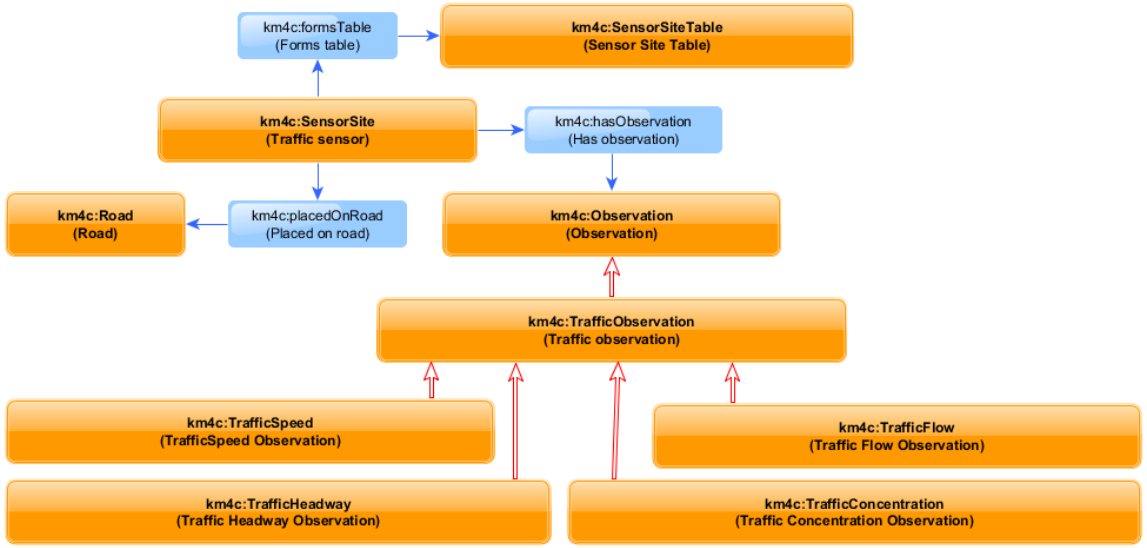
Km4City Ontology: Weather Forecasts

- Municipality
- WeatherReport
- WeatherPrediction



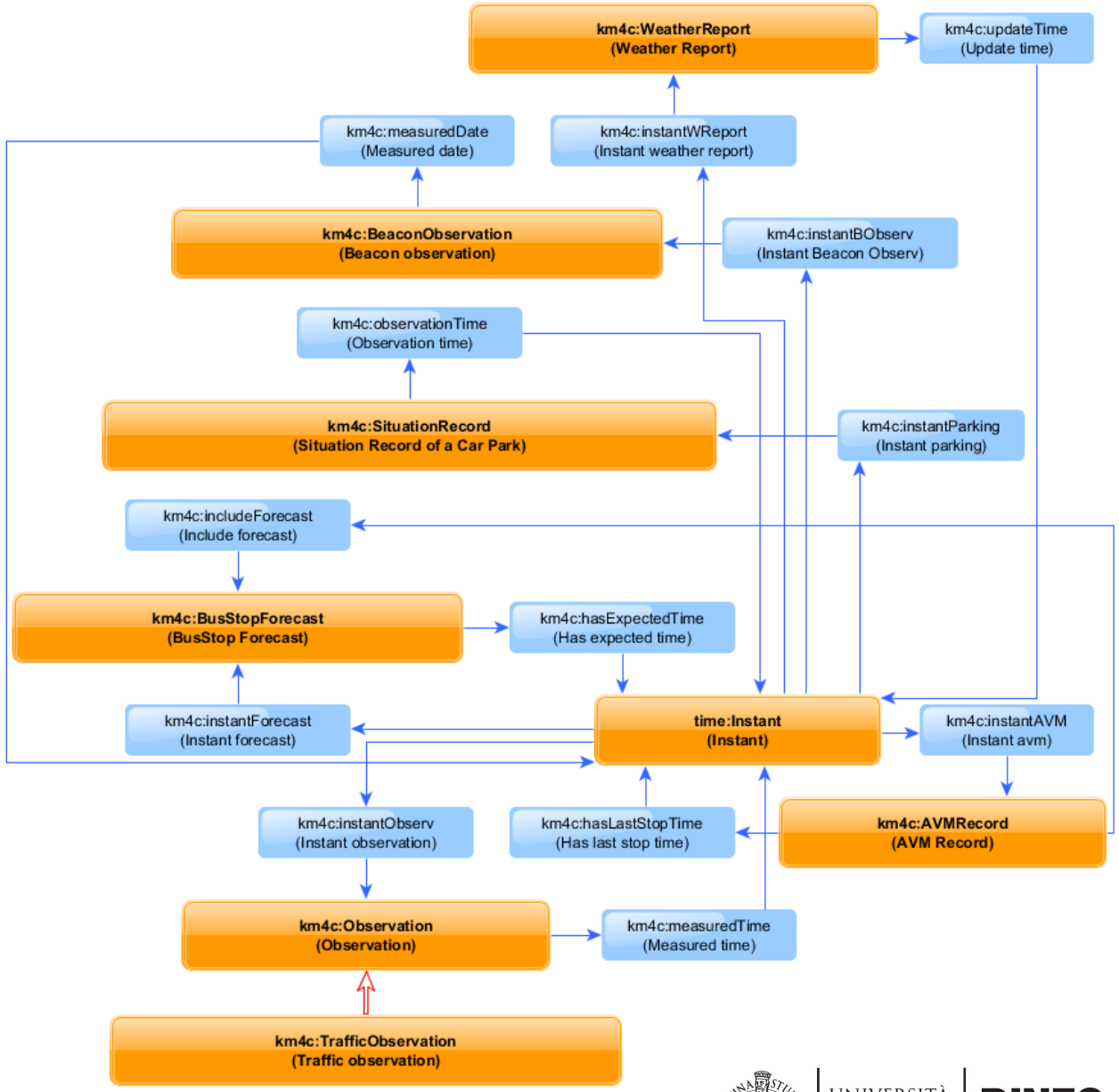
Km4City Ontology: Traffic Sensors

- SensorSiteTable
- SensorSite
- Road
- TrafficObservation
  - TrafficSpeed
  - TrafficFlow
  - TrafficHeadway
  - TrafficConcentration



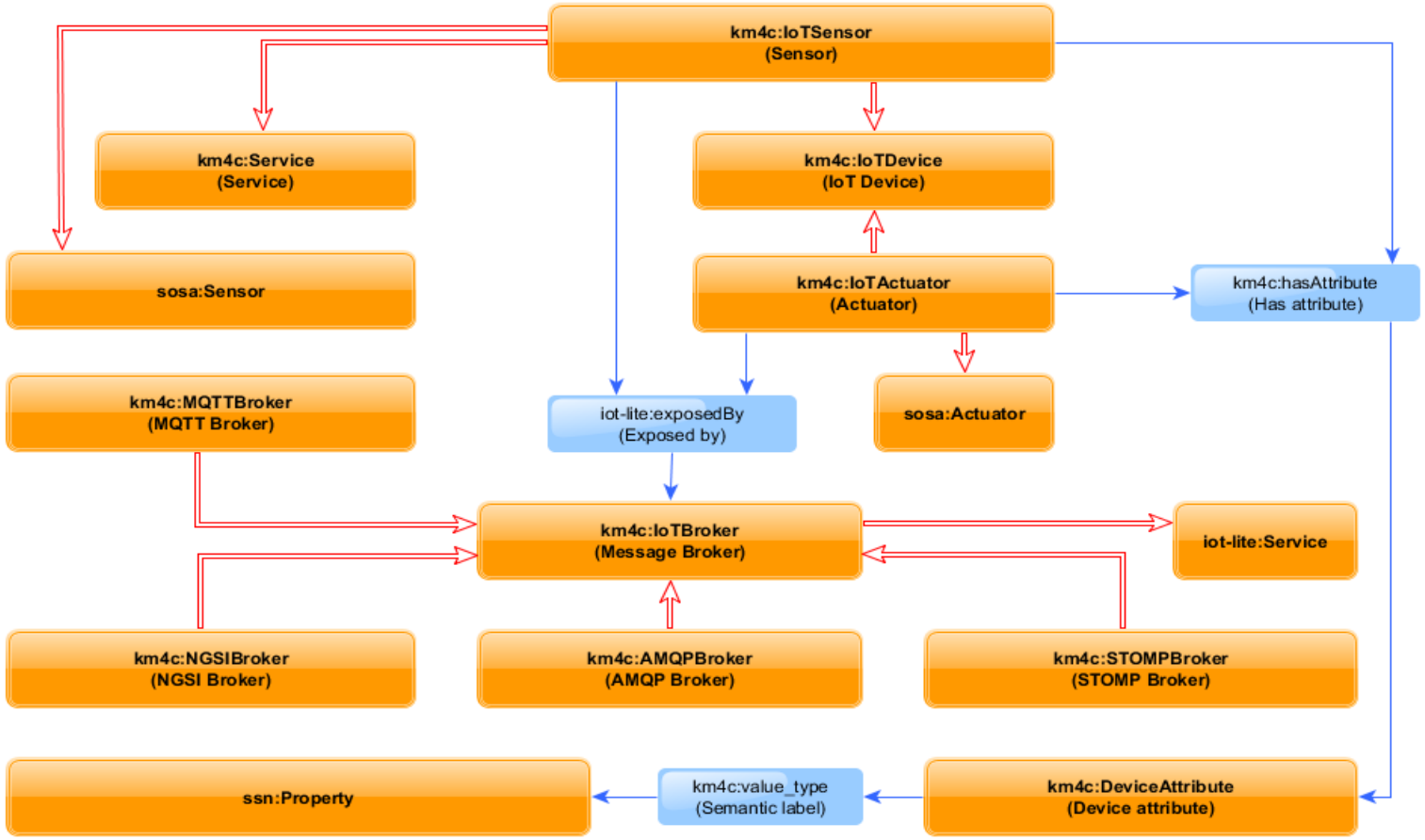
Km4City Ontology: Temporal domain (When Time Matters)

- It is the section of the Km4City Ontology where the most of the modelling of the real-time events/statuses can be found:
  - Weather
  - Parkings
  - Public Transport
  - Beacons



Km4City Ontology: Internet of Things

- IoTDevice
  - IoTSensor
  - IoTActuator
- DeviceAttribute
- IoTBroker
  - MQTTBroker
  - NGSIBroker
  - AMQPBroker
  - STOMPBroker

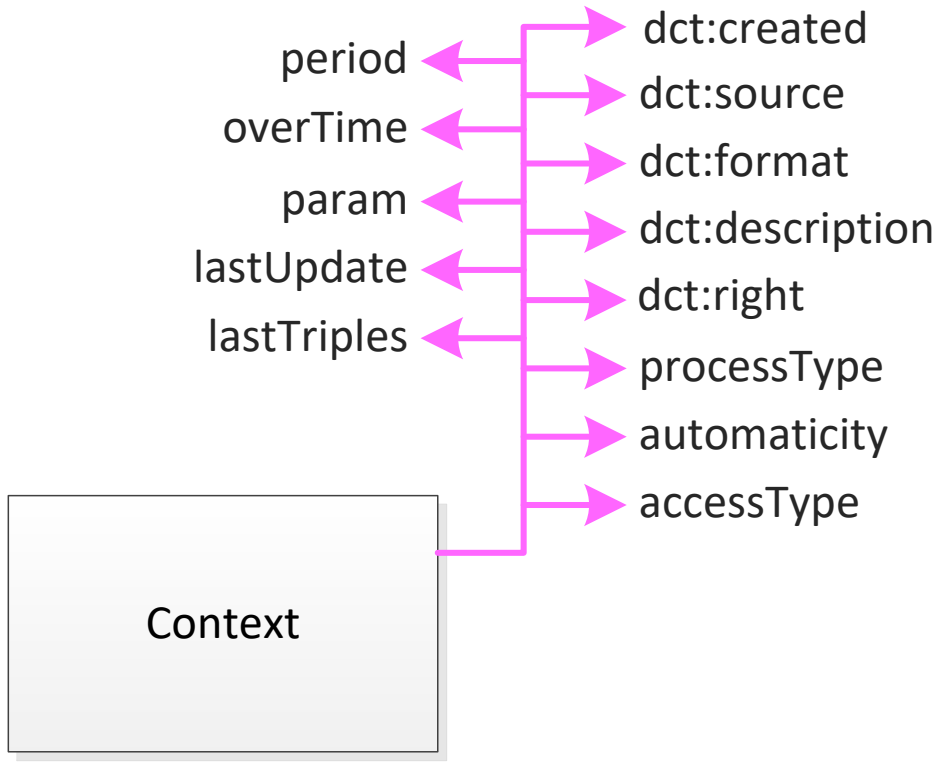


Km4City Ontology: Contexts (Graphs)

- Triples in the Knowledge Base are partitioned in graphs.
- Graphs are something like folders in file systems.
- Each graph is identified through a URI.
- Such URI can be the subject of a triple.

Therefore:

- It makes sense to model predicates that describe graphs.
- The Km4City Ontology includes a set of predicates, each having its own semantic, that are aimed at describing graphs.



Ingesting the Open Street Map: outline

We are going to:

- Introduce some useful tools
- Learn how to setup the environment
- Learn how to keep our local copy of the Open Street Map up-to-date
- Outline the RDB data preparing for triplification
- See how PostGIS helps us preparing RDB data for triplification
- Learn how to configure the triplification through a Sparqlify Mapping Language (SML) script
- See how to exploit the Sparqlify for triplifying RDB data

Tools

- …
- PostgreSQL
  - https://www.postgresql.org/
- PostGIS
  - PostGIS is a spatial database extender for PostgreSQL object-relational database. It adds support for geographic objects allowing location queries to be run in SQL. (https://postgis.net/)
- Osmosis
  - “Osmosis is a command line Java application for processing OSM data.” (https://wiki.openstreetmap.org/wiki/Osmosis)
- Sparqlify
  - “Sparql -> SQL Rewriter enabling virtual RDB -> RDF mappings” (https://github.com/SmartDataAnalytics/Sparqlify)

Ingesting the Open Street Map: Setup (1)

1. `sudo apt install **postgresql-9.4-postgis-2.1** openjdk-7-jre-headless`
2. `sudo apt install **osmosis**`
3. `sudo -u **postgres** **createuser** -s your_username`
4. `createdb **pgsimple**`
5. `psql -d pgsimple 'CREATE EXTENSION **postgis;**'`
6. `psql -d pgsimple -f osmosis_dir/script/**pgsimple_schema_0.6.sql**`

(https://wiki.openstreetmap.org/wiki/Osmosis/PostGIS_Setup)

Ingesting the Open Street Map: Setup (2)

- **pgsimple_schema**
  - nodes
    - node_tags
  - ways
    - way_nodes
    - way_tags
  - relations
    - relation_members
    - Relation_tags

Ingesting the Open Street Map: Populate RDB

- Get the extract of your interest from a repository of your choice. At DISIT, we rely on Geofabrick (http://download.geofabrik.de/).

-
```
osmosis
    --read-pbf extract.osm.pbf
    --write-pgsql database=pgsimple
                  user=your_username
                  password=your_password
```

Ingesting the Open Street Map: Update

- osmosis
  --read-xml-change file="update.osc"
  --write-pgsimp-change database="pgsimple"

Example

https://wiki.openstreetmap.org/wiki/OsmChange

```
<osmChange version="0.6" generator="acme osm editor">
    <modify>
        <node id="1234" changeset="42" version="2" lat="12.1234567" lon="-8.7654321">
            <tag k="amenity" v="school"/>
        </node>
    </modify>
</osmChange>
```

This is the changeset to modify that single node. The outermost tag is *osmChange*. Within that are three possible types of nodes:

- create
- modify
- delete

Preparing Triplification: Outline (1)

- Once you have the Open Street Map loaded on your local RDB, you have to create and populate one or more **additional RDB tables** whose fields (ideally) are: *subject*, *property*, *value*
- This way, RDB queries that you have to execute at the triplification step are **the simplest possible**
  - Keeping RDB queries the simplest possible in the Sparqlify configuration document is a must, since Sparqlify attempts to optmize SQL queries, and it leads to unreasonably long computation times for non-trivial SQL queries
- Functions that are made available by the **PostGIS extension** have a key role for the effectiveness, and efficiency, of RDB preparing

Preparing Triplification: Outline (2)

- Queries that you perform for preparing the triplification, are expected to reflect a **mapping** of OSM model to the Km4City Ontology (or your own destination data model), that you have defined in first
- When defining the mapping, you have to reply, as an example, to questions such as:
  - How are roads represented in the Open Street Map once I have loaded it to a pg_simple RDB schema?
  - How are roads represented in the Km4City data model?
  - So, *where* do I have to put *what*?

Preparing Triplification: PostGIS (1)

- CREATE INDEX index ON table USING **GIST** (field); (https://postgis.net/docs/manual-1.3/ch03.html#id434676)
- **ST_AddPoint** - Adds a point to a LineString (https://postgis.net/docs/ST_AddPoint.html)
- **ST_AsText** - Returns the Well-Known Text representation of the geometry/geography (https://postgis.net/docs/ST_AsText.html)
- **ST_Centroid** - Computes the geometric center of a geometry (https://postgis.net/docs/ST_Centroid.html)
- **ST_Collect** - Output type can be a MULTI* or a GEOMETRYCOLLECTION (https://postgis.net/docs/ST_Collect.html)

Preparing Triplification: PostGIS (2)

- **ST_ConvexHull** - The convex hull of a geometry represents the minimum convex geometry that encloses all geometries within the set (https://postgis.net/docs/ST_ConvexHull.html)
- **ST_Covers(Geo_A, Geo_B)** - Returns 1 (TRUE) if no point in Geometry/Geography B is outside Geometry/Geography A. (https://postgis.net/docs/ST_Covers.html)
- **ST_Distance** – Compute the distance between geometries or geographies. (https://postgis.net/docs/ST_Distance.html)
- **ST_Envelope** - Returns the minimum bounding box for the supplied geometry. (https://postgis.net/docs/ST_Envelope.html)

Preparing Triplification: PostGIS (3)

- **ST_GeomFromText** - Constructs a geometry object from a OGC WKT string. (https://postgis.net/docs/ST_GeomFromText.html)
- **ST_LineMerge** - Returns a (set of) LineString(s) formed by sewing together the constituent line work of a MULTILINESTRING. (https://postgis.net/docs/ST_LineMerge.html)
- **ST_MakeLine** – It makes a line from a set of points (different formats allowed). (https://postgis.net/docs/ST_MakeLine.html)
- **ST_MakePolygon** - Creates a Polygon formed by the given shell. (https://postgis.net/docs/ST_MakePolygon.html)

Preparing Triplification: PostGIS (4)

- **ST_PointN** - Return the Nth point in a single linestring or circular linestring in the geometry. (https://postgis.net/docs/ST_PointN.html)
- **ST_X** - Return the X coordinate (longitude) of the point, or NULL if not available. (https://postgis.net/docs/ST_X.html)
- **ST_Y** - Return the Y coordinate (latitude) of the point, or NULL if not available. (https://postgis.net/docs/ST_Y.html)

Triplifying: Sparqlify Mapping Language (1)

```
select * from Milestone
```



```
Graph ?graph_uri {
?ml a km4c:Milestone .
?ml dct:identifier ?identifier .
?ml km4c:text ?distance.
?ml geo:long ?long .
?ml geo:lat ?lat .
?ml km4c:isInElement ?re
}}
```



```
?graph_uri = uri(?graph_uri)
?ml = uri(concat("http://www.disit.org/km4city/resource/", ?ml_id))
?identifier = plainLiteral(?ml_id)
?distance = plainLiteral(?distance)
?long = typedLiteral(?long, "http://www.w3.org/2001/XMLSchema#float")
?lat = typedLiteral(?lat, "http://www.w3.org/2001/XMLSchema#float")
?re = uri(concat("http://www.disit.org/km4city/resource/", ?re_id))
```

Triplifying: Sparqlify Mapping Language (2)

mapping.sml

```
Create view Milestone As

Construct {
Graph ?graph_uri {
?ml a km4c:Milestone .
?ml dct:identifier ?identifier .
?ml km4c:text ?distance.
?ml geo:long ?long .
?ml geo:lat ?lat .
?ml km4c:isInElement ?re
}}

With
?graph_uri = uri(?graph_uri)
?ml = uri(concat("http://www.disit.org/km4city/resource/", ?ml_id))
?identifier = plainLiteral(?ml_id)
?distance = plainLiteral(?distance)
?long = typedLiteral(?long, "http://www.w3.org/2001/XMLSchema#float")
?lat = typedLiteral(?lat, "http://www.w3.org/2001/XMLSchema#float")
?re = uri(concat("http://www.disit.org/km4city/resource/", ?re_id))

From [[
select * from Milestone
]]
```

```
./sparqlify.sh
    -m mapping.sml
    -h rdb_host
    -d pgsimple
    -U pgsimple_user
    -W pgsimple_pwd
    -o ntriples
    --dump
```

UNIVERSITÀ DEGLI STUDI FIRENZE

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DISIT
DISTRIBUTED SYSTEMS AND INTERNET TECHNOLOGIES LAB

DataCom 2018
The Fourth IEEE International Conference on Big Data Intelligence and Computing

Real-Time Traffic Estimation of Unmonitored Roads

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Overview

We aim to improve the urban mobility through a **general** and **self-adaptive** model for a **low-cost** traffic reconstruction at **real-time** in **every position** of the city.

We propose to use a **fluid-dynamic traffic model** on road networks getting the road infrastructure and traffic restrictions from the **Open Street Map** and the traffic sensors specifications and detections from the **publicly available Open Data**.

Table of contents

- **Features**: What we have achieved/we aim to achieve
- **Context**: Km4City – A Knowledge Model for Smart Cities
- **Data sources**: Open Street Map, Traffic sensors and detections
- **Modeling**: A fluid-dynamic traffic model on road networks
- **Weights**: Initialization and Time-Based Stochastic Learning
- **Validation**: Method and Results of the Accuracy Assessment
- **Displaying**: How the results are made available to users
- **Future Developments**: Improvements & new threads of research

Features

Low-cost
It uses stationary sensors that were already deployed in the city.

Unobtrusive
It does not require users to take any action (install app, submit data…).

Visual
Traffic flows are displayed on a street map through colored lines.

Open
Methods and software are made available under an open license.

Real-Time
The reconstruction is updated after every new traffic sensor detection.

General
No simplistic assumption is made about the street graph.

Dense
The reconstruction is made at every location in the area of interest.

Verified
The accuracy of the reconstruction has been rigorously verified.

Km4City – A Knowledge Model for Smart Cities

An **Open Urban Platform for a Sentient Smart City**, aimed at:

- Implementing the city vision;
- Monitoring the city evolution;
- Providing new services for improving the quality of life of the citizens;
- Supporting the economic grow of the city;
- Promoting virtuous behaviours.

Briefly, we aim to support **cities that produce** with happy and proud **citizens** and with crowds of enthusiastic **tourists** and **investors**.

The Open Street Map

- OpenStreetMap powers map data on **thousands** of web sites, mobile apps, and HW devices.
- It is built by a **community** of mappers that contribute and maintain data about roads, trails, cafés, railway stations, and much more, all over the world.
- It provides **open data**: you are free to use it for any purpose as long as you credit OpenStreetMap and its contributors.
- **OSM data is stored in a RDB, and then transformed and stored in a triplestore, based on a mapping of the OSM data model to the Km4City Ontology street graph modelling.**

Sensors and detections

- Traffic Sensors static information (identifier, geolocation, street address, technical specifications…) and the traffic flow detections (sensor, timestamp, detected traffic flow, estimated speed…) all come from publicly available Open Data.
- They are managed through ETL processes, and stored in a No-SQL database.
- The traffic reconstruction model implementation accesses those data through dedicated APIs. Traffic flows are read every 10 minutes, the refresh frequency of the traffic sensors.

Mathematical Model: A Fluid Dynamics Model

Roads are modelled as if they were water pipelines.

Crossroads are modelled as if they were pipeline junctions.

The flow of the vehicles is modelled as if it was a water flow.

The **law of conservation of the vehicles** applies:

$$\frac{\partial \rho(t,x)}{\partial t} + \frac{\partial f\left(\rho(t,x)\right)}{\partial x} = 0$$

where $\rho(t,x)$ is the vehicular density, $f(\rho(t,x)) = \rho(t,x)v(t,x)$ is the vehicular flux, and $v(t,x)$ is the local speed of the vehicles.

Discretization

The following discretization and simplification of the model is operated:

- Each road is partitioned in segments Δ*x* long.
- The time is partitioned in intervals Δ*t* long.
- Consecutive road segments that belong to the same road and do not start or end to a crossroad are joint for an improved efficiency without loss of accuracy.

Denote (h,m) a bounded time-space region (cell) of duration h and length m. Let $u_m^h = u(t_h, xm) = u(\mathrm{h}\Delta t, m\Delta x)$ be a continuous function defined on (h,m). Denote *F* the numerical flux. Then, the vehicular density results from:

$$u_m^{h+1} = u_m^h - \frac{\Delta t}{\Delta x}\left(F\left(u_m^h, u_{m+1}^h\right) - F\left(u_{m-1}^h, u_m^h\right)\right)$$

Traffic Reconstruction: Application of the Mathematical Model

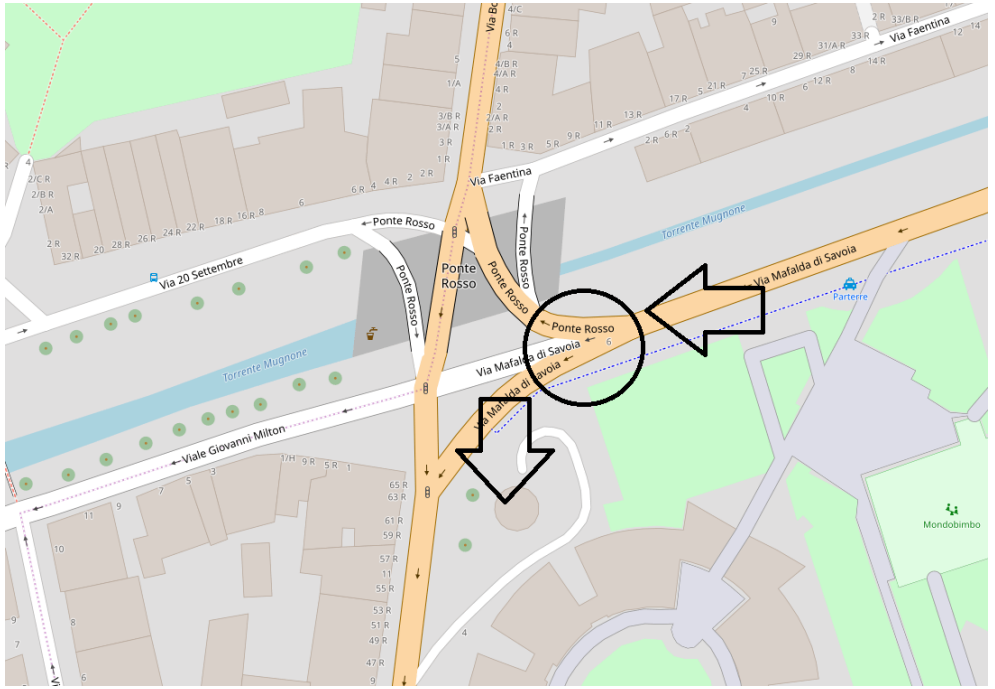
- For each time slot *t*, each traffic sensor detection is interpreted as a **source of traffic** that leads into the segments of road that origin from the node where the sensor is located that has produced the data.
- The distribution of the traffic at crossroads is governed by a **Traffic Distribution Matrix** whose coefficients are based on the ***weights*** of the segments of roads that make the crossroad.

Application of the Mathematical Model

The fork of via Mafalda di Savoia (East), in via Mafalda di Savoia (South),
Viale Giovanni Milton (West) and Via del Ponte Rosso (North), in Florence.

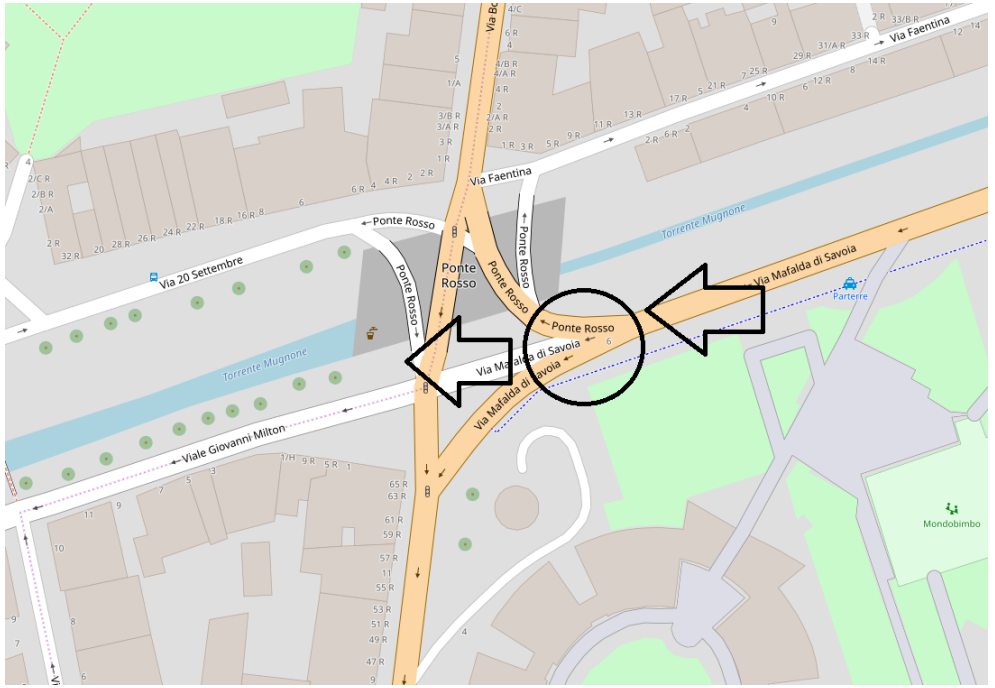
Application of the Mathematical Model

Road Type: primary
Lanes: 2
Designated Lanes: 0
Restrictions: none
Learning Factor: 61
Elem. Type: T.O.C.
Length: 63
Direction: positive
…
Weight: 31.122%



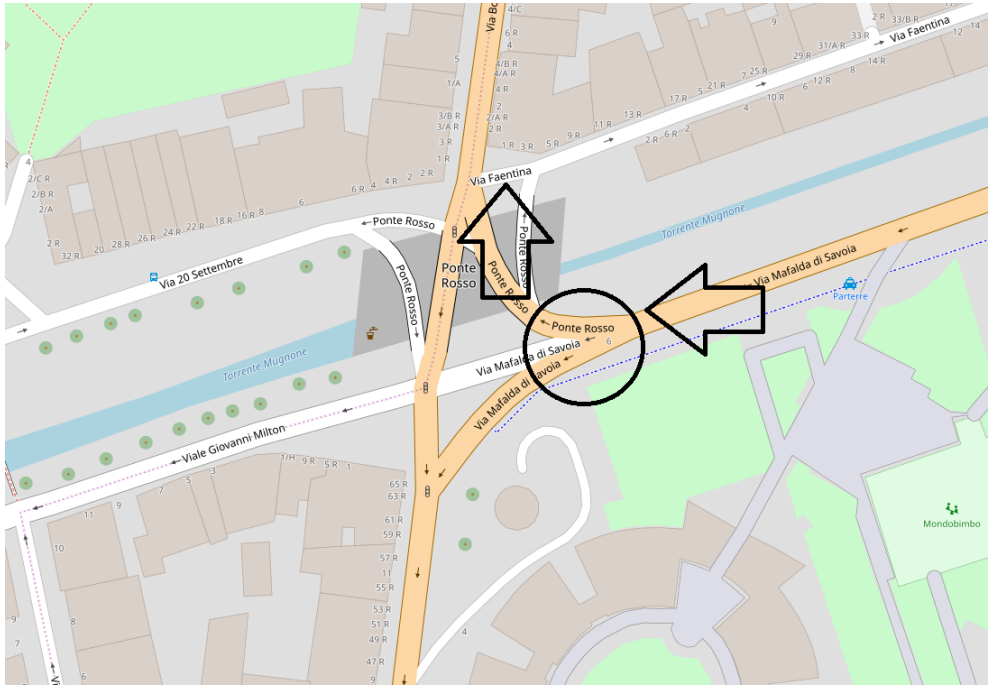
Application of the Mathematical Model

Road Type: tertiary
Lanes: 1
Designated Lanes: 0
Restrictions: none
Learning Factor: 24
Elem. Type: T.O.C.
Length: 51
Direction: positive
…
Weight: 12.245%



Application of the Mathematical Model

Road Type: primary
Lanes: 2
Designated Lanes: 0
Restrictions: none
Learning Factor: 111
Elem. Type: T.O.C.
Length: 60
Direction: positive
…
Weight: 56.633%



Weights Initialization

Weights are **initialized** based on the following:

- **Road type**: motorway, trunk, primary, secondary, tertiary, unclassified, residential, service;
- **Lanes**: how many lanes are drawn on the asphalt, also considering possible restrictions (e.g. lanes reserved to public transport);
- **Traffic restrictions**: examples are mandatory/forbidden directions at crossroads, speed limits, limited traffic zones.

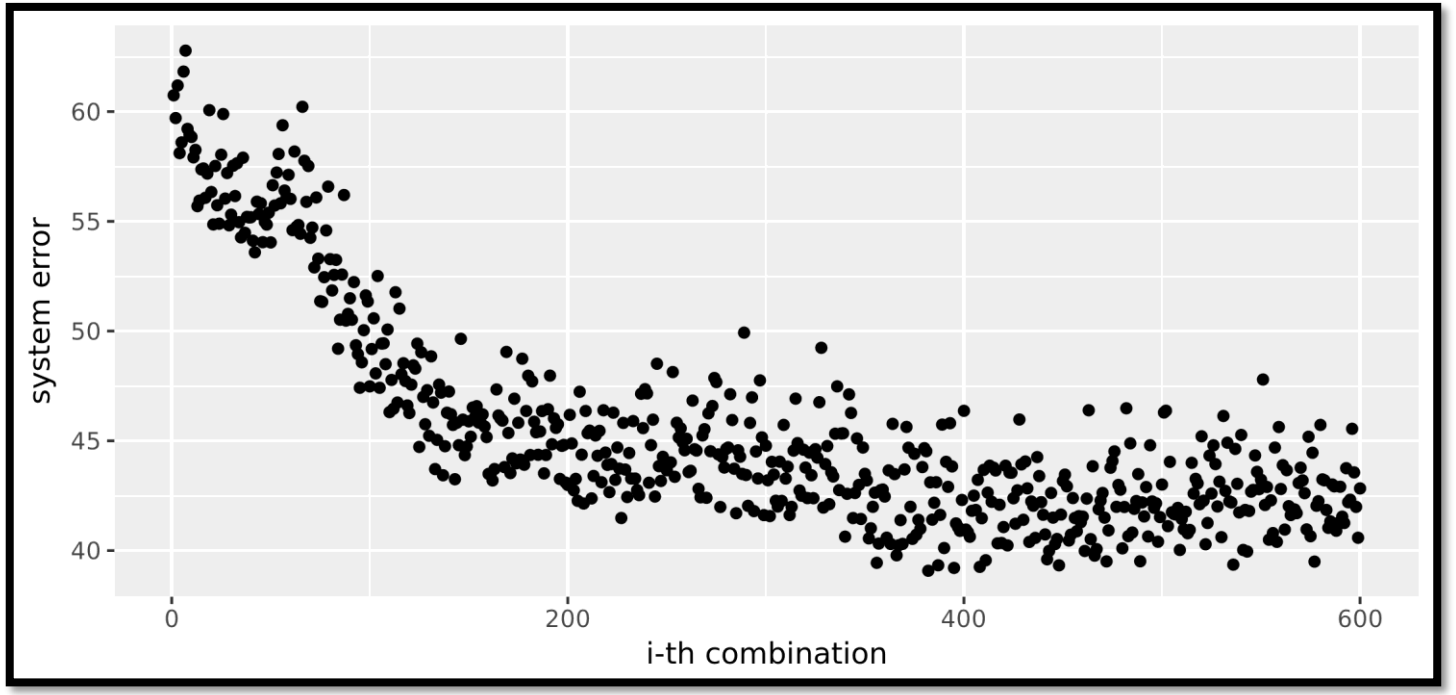
Stochastic Learning

It has been observed that:

- The way how vehicles distribute at crossroads varies depending of the day of the week, and of the time of the day;
- A random variation of some weights is very likely to lead to an improved accuracy;
- If no improvements are achieved after *n* attempts, it is reasonable to move anyway to the best of the last *n* configs.

An offline process is run, based on the above, that leads to time-based weight adjustments, aimed at an improved accuracy.

Stochastic Learning



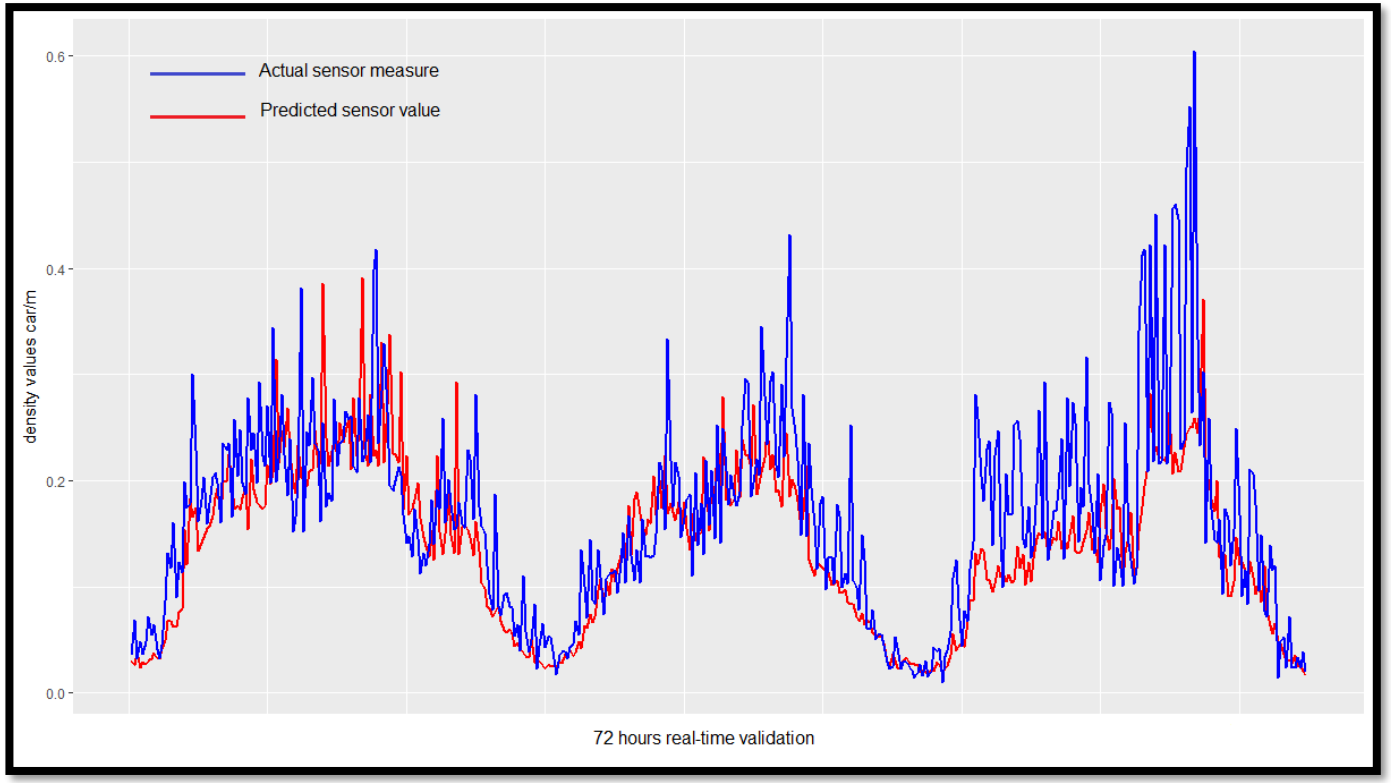
In the x axis, the number of the learning iterations. In the y axis, the (decreasing) system error.

Validation & Results

- Let the **error at a sensor at a given time *t*** be the percentage error computed removing a *given sensor* from the inputs and comparing the traffic flow *reconstructed* at the sensor with the traffic flow *detected* by the sensor, at the given time.
- Let the **system error over a time period *T*** be the average of the system errors computed over all the traffic sensors and all the times ***t*** $\in$ ***T***.

The system error has been computed to be the **30%** about.

Validation & Results

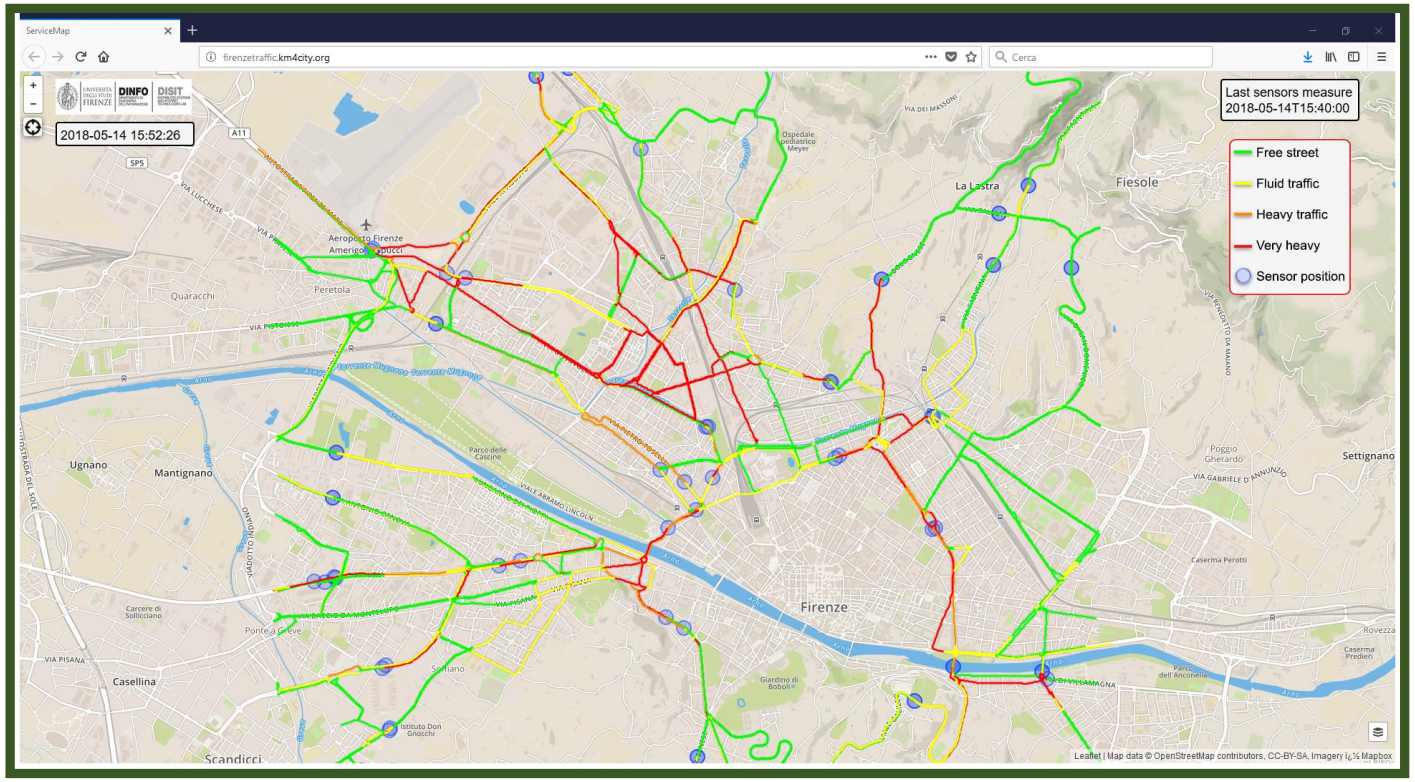


The diagram refers to one in particular of the sensors, and it displays the predicted vs actual values over the time in the 72 hrs validation.

Displaying of results

- Segments of road are categorized based on the road type and the number of lanes.
- Segments of each category that have one at least of the extremities that coincide with a traffic sensor, are used for determining the range of the traffic flows that can be observed on the specific category of segments.
- For each segment category, the range is partitioned into four subranges, that correspond to the four colors that you can find on the map.
- The reconstruction is presented to users through colored lines traced over the road paths on the city map.
- The date and time when the most up-to-date values from the sensors have been acquired can also be seen at the top-right corner of the map.

Displaying of results



A screenshot from the live app at **http://firenzetraffic.km4city.org**
Note that a separate line is drawn for each of the traffic directions.

Future Developments

- Enrichment of the model with the **Points Of Interest** (POI)
- Improvement of the **efficiency of the reconstruction**
- **Online** Time-Based Stochastic Learning
- Efficient **zooming**
- **Multi-modal** traffic reconstruction
- Integration in the **Km4City Service Map**
- **Comparison** with other emerging approaches
- **Your very appreciated suggestions** ☺

DATAMETER

UNIVERSITÀ DEGLI STUDI FIRENZE
DINFO DIPARTIMENTO DI INGEGNERIA DELL'INFORMAZIONE
DISIT DISTRIBUTED SYSTEMS AND INTERNET TECHNOLOGIES LAB

We are going to…

- Introduce the purpose of this research activity
- Discuss the metrics that are computed at the endpoint level
- Discuss the (endpoint) metrics that are derived from the former, and that are useful for the automatic characterization of triplestores
- Discuss the High-Level metrics, i.e. those metrics that relate to the whole set of the monitored endpoints
- See how values computed for the endpoint-level metrics can be exploited for performing an automatic characterization of triplestores
- Present (partial) results

Purpose

- For each of the monitored triplestores, and for the universe of the Linked Open Data:
  - Quantifying :
    - Quality
    - Cost

    Through the measuring of:
    - Cohesion
    - Connection
  - Describing (contents, structure, …)
  - Characterizing (structurally)
  - Monitoring (and analyzing) the evolution of the above *over the time*

Endpoint Directories

- Web Services exist that provide listings of SPARQL endpoints and triplestores, together with some metadata

- We exploit three of those, to retrieve the list of the SPARQL endpoints to be monitored:
  - https://old.datahub.io
  - http://data.gov.uk
  - http://linkeddatacatalog.dws.informatik.uni-mannheim.de

Alive Endpoint Metric

- Aimed at verifying:
  - the possibility of opening a connection to the database server instance
  - the ability of the server to provide a valid response to the SPARQL query below here in 10 seconds at most:

```
SELECT * { ?s ?p ?o } LIMIT 1
```

Triples Count Metric

- `SELECT COUNT(*) { ?s ?p ?o }`

Measurement # 15106

https://www.disit.org/datameter/resource/measurement?id=15106

Properties

Property Name	Property Value
Resource Category	Measurement
Metric	Triples Count Metric
Endpoint	http://dblp.l3s.de/d2r/sparql
Thread	disitms2
Duration	31022
Completion	2018-07-27 15:30:45.0
Result	450073

Class Count Metric

- `SELECT COUNT(DISTINCT ?o) { ?s a ?o }`

Measurement # 15116

https://www.disit.org/datameter/resource/measurement?id=15116

Properties

Property Name	Property Value
Resource Category	Measurement
Metric	Class Count Metric
Endpoint	http://dblp.l3s.de/d2r/sparql
Thread	disitms4
Duration	347
Completion	2018-07-27 15:40:52.0
Result	6

Instance Count Metric

- `SELECT COUNT(DISTINCT ?s) { ?s a ?o }`

Measurement # 15129

http://www.disit.org/datameter/resource/measurement?id=15129

Properties

Property Name	Property Value
Resource Category	Measurement
Metric	Instance Count Metric
Endpoint	http://data.open.ac.uk/query
Thread	disitms8
Duration	33504
Completion	2018-07-27 16:46:28.0
Result	777244

Same As Metric

- `SELECT count(*) { ?s owl:sameAs ?o }`

Measurement # 15134

http://www.disit.org/datameter/resource/measurement?id=15134

Properties

Property Name	Property Value
Resource Category	Measurement
Metric	Same As Metric
Endpoint	http://dblp.l3s.de/d2r/sparql
Thread	disitms4
Duration	744
Completion	2018-07-27 16:59:30.0
Result	29488

Subclass Count Metric

- `SELECT count(*) { ?c rdfs:subClassOf ?sc }`

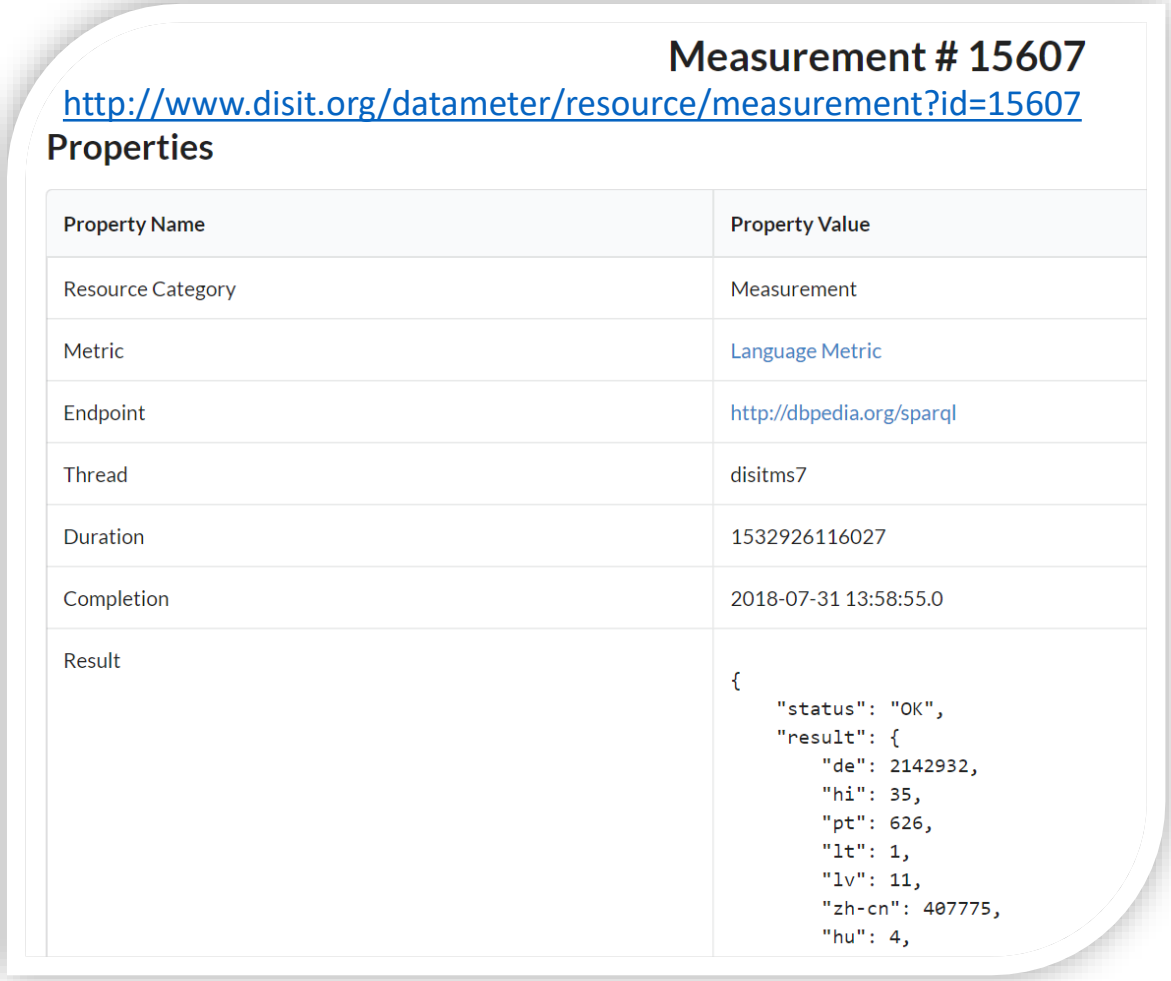
Measurement # 15140

http://www.disit.org/datameter/resource/measurement?id=15140

Properties

Property Name	Property Value
Resource Category	Measurement
Metric	Subclass Count Metric
Endpoint	https://ruian.linked.opendata.cz/sparql
Thread	disitms2
Duration	200
Completion	2018-07-27 17:01:09.0
Result	22

Language Metric



Measurement # 15607

http://www.disit.org/datameter/resource/measurement?id=15607

Properties

Property Name	Property Value
Resource Category	Measurement
Metric	Language Metric
Endpoint	http://dbpedia.org/sparql
Thread	disitms7
Duration	1532926116027
Completion	2018-07-31 13:58:55.0
Result	{ "status": "OK", "result": { "de": 2142932, "hi": 35, "pt": 626, "lt": 1, "lv": 11, "zh-cn": 407775, "hu": 4,

- When you insert a triple having a string literal as filler, you *can* explicitly indicate the language in which the literal is written, through a query such as:

```
INSERT DATA {
<http://foo.com#s>
rdfs:label "str"@en }
```

- The **`lang`** function is native in the SPARQL language, and it allows to get the language of a literal variable, if available.

Middle-Level Metrics

- **Subclass Ratio Metric**
  - The share of the classes that are specializations of some other class(es)
  - `Subclass Count Metric / Class Count Metric`
- **Localized Triples Ratio**
  - The share of the literals that bear a language indication
  - Based on: Language Metric, Triples Count Metric
- **Triples Per Resource**
  - The average size of a resource (the avg # of triples per subject)
  - `Triples Count Metric / Instance Count Metric`
- **Languages Count Metric**
  - The count of the different languages that appear in the triplestore
  - Based on: Language Metric

Alive Endpoints

Measurement # 16758

https://www.disit.org/datameter/resource/measurement?id=16758

Properties

Property Name	Property Value
Resource Category	Measurement
Metric	Alive Endpoints
Endpoint	All (Global Measure)
Thread	disitms3_4
Duration	1535558679817
Completion	2018-08-29 18:04:39.0
Result	{ "status": "OK", "result": 185 }

The metric provides the total number of the endpoints that can be reached and that provide a valid response to SPARQL queries among those that can be found listed in the directories that we access for our investigation.

Alive Endpoints Ratio

Measurement # 16759

https://www.disit.org/datameter/resource/measurement?id=16759

Properties

Property Name	Property Value
Resource Category	Measurement
Metric	Alive Endpoints Ratio
Endpoint	All (Global Measure)
Thread	disitms3_4
Duration	1535558680251
Completion	2018-08-29 18:04:40.0
Result	{ "status": "OK", "result": 30.478 }

The metric measures how many are reachable and able to provide a valid response to SPARQL queries among the endpoints that can be found listed in the triplestore directories.

Global Instance Count Metric

Measurement # 16765

https://www.disit.org/datameter/resource/measurement?id=16765

Properties

Property Name	Property Value
Resource Category	Measurement
Metric	Global Instance Count Metric
Endpoint	All (Global Measure)
Thread	disitms3_4
Duration	1535558686995
Completion	2018-08-29 18:04:47.0

Result	{
	"status": "OK",
	"result": 1163441275
	}

The metric provides the total number of the resources that can be found inspecting all the monitored (and alive) endpoints.

Average Instance Count Metric

Measurement # 17371

https://www.disit.org/datameter/resource/measurement?id=17371

Properties

Property Name	Property Value
Resource Category	Measurement
Metric	Average Instance Count Metric
Endpoint	All (Global Measure)
Thread	disitms3_4
Duration	1535877788063
Completion	2018-09-02 10:43:08.0
Result	{ "status": "OK", "result": 6288871.757 }

The metric provides the average number of the resources that can be found in a triplestore, computed inspecting all the monitored (and alive) endpoints.

Class Ranking

Measurement # 16778

https://www.disit.org/datameter/resource/measurement?id=16778

Properties

Property Name	Property Value
Resource Category	Measurement
Metric	Class Ranking
Endpoint	All (Global Measure)
Thread	disitms3_4
Duration	1535558901781
Completion	2018-08-29 18:10:28.0
Result	


```
{
    "status": "OK",
    "result": {
        "http://bio2rdf.org/dbsnp_vocabulary:Resource": 669704382,
        "http://bio2rdf.org/pharmgkb_vocabulary:Variation": 594836352,
        "http://purl.uniprot.org/core/Cluster": 588752874,
        "http://purl.uniprot.org/core/Gene": 567596065,
        "http://bio2rdf.org/ctd_vocabulary:Resource": 549477459,
        "http://bio2rdf.org/ctd_vocabulary:Gene-Disease-Association": 477255510,
        "http://purl.uniprot.org/core/Protein": 364317901,
        "http://bio2rdf.org/ncbigene_vocabulary:Resource": 273011060,
        "http://purl.uniprot.org/core/Nucleotide_Resource": 263705806,
        "http://bio2rdf.org/clinicaltrials_vocabulary:Resource": 262796238,
        "http://bio2rdf.org/kegg_vocabulary:Resource": 221373594,
        "http://purl.uniprot.org/core/Transmembrane_Annotation": 212361446,
        "http://geovocab.org/geometry#Geometry": 191039674,
        "http://purl.uniprot.org/core/Domain_Extent_Annotation": 169010566,
        "http://purl.uniprot.org/core/Member_Of_Redudant_Proteome": 145868062,
        "http://purl.uniprot.org/core/Caution_Annotation": 134028804,
        "http://purl.uniprot.org/core/Simple_Sequence": 120801840,
        "http://bio2rdf.org/gi_vocabulary:Resource": 118895644,
        "http://purl.uniprot.org/core/Strain": 113559082,
        "http://purl.uniprot.org/core/Resource": 113170541,
        "http://bio2rdf.org/genbank_vocabulary:Resource": 107841328,
        "http://bio2rdf.org/refseq_vocabulary:Resource": 101215380,
        "http://bio2rdf.org/goa_vocabulary:GO-Annotation": 79307829,
        "http://bio2rdf.org/goa_vocabulary:Resource": 68601141,
        "http://biohackathon.org/resource/faldo#ExactPosition": 66262106,
        "http://purl.org/linked-data/cube#Observation": 65600209,
        "http://bio2rdf.org/clinicaltrials_vocabulary:Event-Count": 61012028,
        "http://purl.uniprot.org/core/Similarity_Annotation": 60042846,
        "http://purl.uniprot.org/core/Transcript_Resource": 56528115,
        "http://bio2rdf.org/uniprot_vocabulary:Resource": 54626712,
        "http://www.w3.org/ns/prov#Entity": 52152052,
        "http://bio2rdf.org/ctd_vocabulary:Chemical-Disease-Association": 47922112,
        "http://bio2rdf.org/ensembl_vocabulary:Resource": 46968320,
        "http://www.w3.org/2002/07/owl#Class": 45861994,
        "http://imgpedia.dcc.uchile.cl/ontology#ImageRelation": 44451377,
        "http://bio2rdf.org/affymetrix_vocabulary:Resource": 41046768,
        "http://xmlns.com/foaf/0.1/Document": 40485549,
        "http://bio2rdf.org/wormbase_vocabulary:Resource": 39231136,
        "http://bio2rdf.org/affymetrix_vocabulary:Probeset": 38924760,
```

Class Ratio

Measurement # 16779

https://www.disit.org/datameter/resource/measurement?id=16779

Properties

Property Name	Property Value
Resource Category	Measurement
Metric	Class Ratio
Endpoint	All (Global Measure)
Thread	disitms3_4
Duration	1535559029067
Completion	2018-08-29 18:12:29.0
Result	


```
{
    "status": "OK",
    "result": {
        "http://www.w3.org/2002/07/owl#Class": 75.676,
        "http://www.w3.org/2002/07/owl#Ontology": 73.514,
        "http://www.w3.org/2002/07/owl#AnnotationProperty": 70.811,
        "http://www.w3.org/1999/02/22-rdf-syntax-ns#Property": 63.784,
        "http://www.w3.org/2002/07/owl#ObjectProperty": 63.243,
        "http://www.w3.org/2002/07/owl#DatatypeProperty": 62.162,
        "http://www.w3.org/2000/01/rdf-schema#Class": 58.919,
        "http://xmlns.com/foaf/0.1/Person": 55.676,
        "http://www.openlinksw.com/schemas/virtrdf#QuadMapValue": 52.432,
        "http://www.openlinksw.com/schemas/virtrdf#array-of-QuadMap": 52.432,
        "http://www.openlinksw.com/schemas/virtrdf#QuadMap": 52.432,
        "http://www.openlinksw.com/schemas/virtrdf#QuadMapFormat": 52.432,
        "http://www.openlinksw.com/schemas/virtrdf#array-of-QuadMapColumn": 52.432,
        "http://www.openlinksw.com/schemas/virtrdf#QuadMapColumn": 52.432,
        "http://www.openlinksw.com/schemas/virtrdf#QuadStorage": 52.432,
        "http://www.openlinksw.com/schemas/virtrdf#array-of-string": 52.432,
        "http://www.openlinksw.com/schemas/virtrdf#QuadMapATable": 52.432,
        "http://www.openlinksw.com/schemas/virtrdf#array-of-QuadMapATable": 52.432,
        "http://www.openlinksw.com/schemas/virtrdf#QuadMapFText": 52.432,
        "http://www.openlinksw.com/schemas/virtrdf#array-of-QuadMapFormat": 52.432,
        "http://www.w3.org/2002/07/owl#OntologyProperty": 47.568,
        "http://www.w3.org/2002/07/owl#Restriction": 47.027,
        "http://www.w3.org/ns/sparql-service-description#Service": 44.324,
        "http://www.w3.org/2002/07/owl#FunctionalProperty": 35.135,
        "http://www.w3.org/2002/07/owl#InverseFunctionalProperty": 35.135,
        "http://rdfs.org/ns/void#Dataset": 32.973,
        "http://www.w3.org/2002/07/owl#TransitiveProperty": 32.432,
        "http://www.w3.org/2004/02/skos/core#Concept": 31.892,
        "http://www.w3.org/2002/07/owl#SymmetricProperty": 31.351,
        "http://www.w3.org/2002/07/owl#Thing": 30.811,
        "http://www.w3.org/2000/01/rdf-schema#Datatype": 30.27,
        "http://xmlns.com/foaf/0.1/Organization": 29.189,
        "http://www.w3.org/2002/07/owl#Axiom": 28.108,
        "http://purl.org/goodrelations/v1#Offering": 27.027,
        "http://purl.org/goodrelations/v1#BusinessEntity": 25.946,
        "http://purl.org/goodrelations/v1#PriceSpecification": 24.865,
        "http://xmlns.com/foaf/0.1/Agent": 24.324,
        "http://www.w3.org/2002/07/owl#NamedIndividual": 24.324,
        "http://www.w3.org/2000/01/rdf-schema#Resource": 24.324,
        "http://purl.org/goodrelations/v1#LocationOfSalesOrServiceProvisioning": 23.784,
```

Vocabulary Ranking

Measurement # 11853

https://www.disit.org/datameter/resource/measurement?id=11853

Properties

Property Name	Property Value
Resource Category	Measurement
Metric	Vocabulary Ranking
Endpoint	All (Global Measure)
Thread	disit
Duration	1531488270808
Completion	2018-07-13 15:24:31.0
Result	


```
{
    "status": "OK",
    "result": {
        "http://www.w3.org/1999/02/22-rdf-syntax-ns#": 179,
        "http://www.w3.org/2000/01/rdf-schema#": 164,
        "http://xmlns.com/foaf/0.1/": 131,
        "http://purl.org/dc/terms/": 104,
        "http://www.w3.org/2004/02/skos/core": 93,
        "http://purl.org/dc/elements/1.1/": 47,
        "http://purl.org/goodrelations/v1": 44,
        "http://voag.linkedmodel.org/schema/voag": 31,
        "http://www.w3.org/2003/06/sw-vocab-status/ns": 30,
        "http://schema.org/": 19,
        "http://www.w3.org/ns/prov#": 17,
        "http://creativecommons.org/ns": 16,
        "http://purl.org/vocommons/voaf": 12,
        "http://rdfs.org/sioc/ns#": 12,
        "http://www.ontologydesignpatterns.org/ont/dul/DUL.owl": 11,
        "http://purl.org/linked-data/cube": 11,
        "http://www.w3.org/2006/vcard/ns": 11,
        "http://www.w3.org/ns/org#": 11,
        "http://purl.org/vocab/bio/0.1/": 10,
        "http://purl.org/dc/dcam/": 10,
        "http://purl.org/vocab/vann/": 9,
        "http://www.opengis.net/ont/geosparql": 8,
        "http://usefulinc.com/ns/doap#": 8,
        "http://purl.org/dc/dcmitype/": 8,
        "http://purl.org/ontology/mo/": 8,
        "http://www.lexinfo.net/ontology/2.0/lexinfo": 7,
        "http://purl.org/vocab/changeset/schema": 7,
        "http://purl.org/NET/c4dm/event.owl": 5,
        "http://purl.org/vocab/frbr/core": 5,
        "http://www.openarchives.org/ore/terms/": 4,
        "http://www.w3.org/2008/05/skos-xl": 4,
        "http://linkedevents.org/ontology/": 3,
        "http://purl.org/linked-data/api/vocab#": 3,
        "http://rdfs.org/sioc/types#": 3,
        "http://www.w3.org/ns/oa#": 3,
        "http://www.aktors.org/ontology/portal": 3,
        "http://open.vocab.org/terms": 3,
        "http://purl.org/pav/": 3,
        "http://purl.org/iso25964/skos-thes": 3,
```

Vocabulary Ratio

Measurement # 11854

https://www.disit.org/datameter/resource/measurement?id=11854

Properties

Property Name	Property Value
Resource Category	Measurement
Metric	Vocabulary Ratio
Endpoint	All (Global Measure)
Thread	disit
Duration	1531488272454
Completion	2018-07-13 15:24:33.0
Result	


```
{
    "status": "OK",
    "result": {
        "http://www.w3.org/1999/02/22-rdf-syntax-ns#": 76.17,
        "http://www.w3.org/2000/01/rdf-schema#": 69.787,
        "http://xmlns.com/foaf/0.1/": 55.745,
        "http://purl.org/dc/terms/": 44.255,
        "http://www.w3.org/2004/02/skos/core": 39.574,
        "http://purl.org/dc/elements/1.1/": 20,
        "http://purl.org/goodrelations/v1": 18.723,
        "http://voag.linkedmodel.org/schema/voag": 13.191,
        "http://www.w3.org/2003/06/sw-vocab-status/ns": 12.766,
        "http://schema.org/": 8.085,
        "http://www.w3.org/ns/prov#": 7.234,
        "http://creativecommons.org/ns": 6.809,
        "http://purl.org/vocommons/voaf": 5.106,
        "http://rdfs.org/sioc/ns#": 5.106,
        "http://www.ontologydesignpatterns.org/ont/dul/DUL.owl": 4.681,
        "http://purl.org/linked-data/cube": 4.681,
        "http://www.w3.org/2006/vcard/ns": 4.681,
        "http://www.w3.org/ns/org#": 4.681,
        "http://purl.org/vocab/bio/0.1/": 4.255,
        "http://purl.org/dc/dcam/": 4.255,
        "http://purl.org/vocab/vann/": 3.83,
        "http://www.opengis.net/ont/geosparql": 3.404,
        "http://usefulinc.com/ns/doap#": 3.404,
        "http://purl.org/dc/dcmitype/": 3.404,
        "http://purl.org/ontology/mo/": 3.404,
        "http://www.lexinfo.net/ontology/2.0/lexinfo": 2.979,
        "http://purl.org/vocab/changeset/schema": 2.979,
        "http://purl.org/NET/c4dm/event.owl": 2.128,
        "http://purl.org/vocab/frbr/core": 2.128,
        "http://www.openarchives.org/ore/terms/": 1.702,
        "http://www.w3.org/2008/05/skos-xl": 1.702,
        "http://linkedevents.org/ontology/": 1.277,
        "http://purl.org/linked-data/api/vocab#": 1.277,
        "http://rdfs.org/sioc/types#": 1.277,
        "http://www.w3.org/ns/oa#": 1.277,
        "http://www.aktors.org/ontology/portal": 1.277,
        "http://open.vocab.org/terms": 1.277,
        "http://purl.org/pav/": 1.277,
        "http://purl.org/iso25964/skos-thes": 1.277,
```

Vocabulary Terms Ranking

Measurement # 11855

https://www.disit.org/datameter/resource/measurement?id=11855

Properties

Property Name	Property Value
Resource Category	Measurement
Metric	Vocabulary Terms Ranking
Endpoint	All (Global Measure)
Thread	disit
Duration	1531489375271
Completion	2018-07-13 15:42:56.0
Result	


```
{
    "status": "OK",
    "result": {
        "http://www.w3.org/1999/02/22-rdf-syntax-ns#type": 173,
        "http://www.w3.org/1999/02/22-rdf-syntax-ns#Property": 118,
        "http://www.w3.org/2000/01/rdf-schema#Class": 109,
        "http://www.w3.org/2000/01/rdf-schema#label": 99,
        "http://xmlns.com/foaf/0.1/Person": 94,
        "http://www.w3.org/2000/01/rdf-schema#comment": 83,
        "http://purl.org/dc/terms/created": 82,
        "http://purl.org/dc/terms/modified": 80,
        "http://www.w3.org/2000/01/rdf-schema#subClassOf": 75,
        "http://www.w3.org/2000/01/rdf-schema#subPropertyOf": 73,
        "http://www.w3.org/2000/01/rdf-schema#domain": 73,
        "http://www.w3.org/2000/01/rdf-schema#range": 72,
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        "http://purl.org/goodrelations/v1#PriceSpecification": 37,
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```

Vocabulary Terms Ratio

Measurement # 11856

https://www.disit.org/datameter/resource/measurement?id=11856

Properties

Property Name	Property Value
Resource Category	Measurement
Metric	Vocabulary Terms Ratio
Endpoint	All (Global Measure)
Thread	disit
Duration	1531489377029
Completion	2018-07-13 15:42:57.0
Result	


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        "http://xmlns.com/foaf/0.1/Agent": 16.17,
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```

Triplestores Characterization

- Principal Component Analysis (PCA) is a statistical analysis that allows to identify a minimal set of metrics that are the most suitable for characterizing a triplestore.
- Learn more (and get it explained the formal way) here:
  - Jolliffe, I. (2011). Principal component analysis. In International encyclopedia of statistical science (pp. 1094-1096). Springer, Berlin, Heidelberg.
- PCA is a preliminary step for ***clustering***.
- Inspecting the clusters, one can assign each cluster a (structural/semantic**?**) label → Triplestore characterization

Clusters

- **thesaurus**: controlled and structured vocabulary in which concepts are represented by terms, organized so that relationships between concepts are made explicit, and preferred terms are accompanied by lead-in entries for synonyms or quasi-synonyms
- **list**: a limited set of terms arranged as a simple alphabetical list or in some other logically evident way; containing no relationships of any kind
- **gazetteer**: geospatial dictionary of named and typed places
- **semantic network** : set of terms representing concepts, modeled as the nodes in a network of variable relationship types
- **classification scheme** : schedule of concepts and pre-coordinated combinations of concepts, arranged by classification
- **See also:**
  - **KOS Types Vocabulary** https://github.com/dcmi/repository/blob/master/wikis_pre2016/nkos/mediawiki/NKOS_Vocabularies.md

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