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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
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- 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%3A0000%3Aobj%3Aa863cca5-6dcc-492d-9afa-0c852aa34ae2>
- Open the extracted RDF file with Protégé, and.. Enjoy! 😊



Protégé: Active Ontology

The screenshot displays the Protégé Active Ontology interface. The main window shows the ontology header for 'http://www.disit.org/km4city/schema' with version 1.0.0. The 'Annotations' section includes labels, licenses, and comments. The 'Ontology metrics' panel on the right provides a summary of the ontology's structure, including the number of axioms, classes, and properties.

Ontology header:
Ontology IRI: <http://www.disit.org/km4city/schema>
Ontology Version IRI: e.g. <http://www.disit.org/km4city/schema/1.0.0>

Annotations:
rdfs:label [language: en]
km4city: the DISIT Knowledge Model for City and Mobility
dcterms:license
<https://creativecommons.org/licenses/by-sa/3.0/it/>
rdfs:comment [language: it]
Km4city permette l'interconnessione, la memorizzazione e la successiva interrogazione, di molti dati provenienti da differenti fonti, quali i vari portali della regione toscana (MIIC, muoversi in toscana, osservatorio dei trasporti) o gli stessi Open Data e Linked Data messi a disposizione dai singoli comuni (principalmente Firenze). Si tratta quindi di un'ontologia di notevoli dimensioni, che conviene pertanto suddividere in macroclassi, e per la precisione, attualmente, sono state individuate le seguenti macroclassi:
1. Amministrazione: la prima macroclasse che è possibile individuare, le cui classi principali sono PA, Municipality, Province, Region, Resolution.
2. Stradario: formata dalle classi Road, Node, RoadElement, AdministrativeRoad, Milestone, StreetNumber, RoadLink, Junction, Entry, EntryRule e Maneuver.
3. Punti di Interesse: comprende tutti i servizi, le attività, che possono essere utili al cittadino e che quindi quest'ultimo può aver necessità di ricercare e di raggiungere. La classificazione dei singoli servizi e attività si baserà sulla classificazione precedentemente adottata dalla Regione Toscana. Sono inoltre inclusi in questa macroclasse le Digital Location e gli eventi programmati (dati Real Time) del comune di Firenze.
4. Trasporto Pubblico Locale: attualmente disponiamo dell'accesso ai dati relativi agli orari programmati delle principali aziende TPL, al grafo ferroviario, e ai dati relativi al tempo reale dell'ATAF. Tale macroclasse è quindi formata dalle classi TPLLine, Ride, Route, AVRecord, RouteSection, BusStopForecast, Lot, BusStop, RouteLink, TPLJunction.
5. Sensoristica: anche la macroclasse relativa ai dati provenienti da sensori è in via di sviluppo. Attualmente sono stati integrati nell'ontologia i dati raccolti da vari sensori installati lungo alcune strade di Firenze e dintorni, e quelli relativi ai posti liberi nei principali parcheggi dell'intera regione; è già presente anche la parte relativa agli eventi/emergenze, dove però attualmente i dati raccolti sono in numero molto limitato e altrettanto vecchi di mesi. Oltre a questi dati, sono stati inseriti in questa macroclasse anche quelli relativi alle previsioni meteo del Lamma.
6. Temporale: macroclasse che punta all'inserimento di concetti legati al tempo (istanti di tempo e intervalli di tempo) all'interno dell'ontologia, in modo da poter associare una linea temporale agli avvenimenti registrati e poter riuscire a fare previsioni.
7. Metadati: macroclasse di triple associate al context di ciascun dataset; tali triple raccolgono le informazioni relative a licenza del dataset, se il processo di ingestione è automatizzato completamente, il formato della risorsa, una breve descrizione della risorsa ed altre info sempre legate alla risorsa stessa e al suo processo di ingestione.

Ontology metrics:

Metric	Count
Axiom	15767
Logical axiom count	3625
Declaration axioms count	2671
Class count	1352
Object property count	895
Data property count	386
Individual count	14
Annotation Property count	46
DL expressivity	ALCRIQ(D)
Class axioms	
SubClassOf	1554
EquivalentClasses	2
DisjointClasses	10
GCI count	0
Hidden GCI Count	2
Object property axioms	
SubObjectPropertyOf	37

Imported ontologies:

- Direct Imports:
 - <<http://purl.oclc.org/NET/ssnx/ssn>>
ssn
Ontology IRI: <<http://purl.oclc.org/NET/ssnx/ssn>>
Location: <http://purl.oclc.org/NET/ssnx/ssn>
 - <<http://purl.oclc.org/NET/UNIS/fiware/iot-lite#>>
iot-lite
Ontology IRI: <<http://purl.oclc.org/NET/UNIS/fiware/iot-lite#>>
Location: <C:\Users\msode\OneDrive\Documents\Task - Relazione Dottorato 2018\Material\km4c-ontology\km4city-1-6-5\km4c Virtuosso 1.6.5-RDF.rdf>
 - <<http://www.w3.org/ns/ssn/systems/>>
systems
Ontology IRI: <<http://www.w3.org/ns/ssn/systems/>>
Location: <http://www.w3.org/ns/ssn/systems/>



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 RDFSPPlus 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: Classi

The screenshot displays the Protégé ontology editor interface. The left pane shows a class hierarchy with 'IoTSensor' selected under the 'Service' category. The right pane provides details for the 'IoTSensor' class, including its annotations and description.

Annotations:

- `rdfs:label` [language: it] `Sensore`
- `rdfs:label` [language: en] `Sensor`
- `rdfs:comment` [language: it] `Le istanze di questa classe rappresentano ciascuna un sensore.`
- `rdfs:comment` [language: en] `The instances of this class represent each a sensor.`

Description:

Equivalent To: +

SubClass Of: +

- `attributesStatus` only `xsd:string`
- `created` only `xsd:dateTime`
- `exposedBy` exactly 1 `IoTBroker`
- `format` only `xsd:string`
- `hasAttribute` min 1 `DeviceAttribute`
- `hasSystemCapability` only `SystemCapability`
- `implements` exactly 1 `Procedure`
- `IoTDevice`
- `macaddress` only `xsd:string`
- `model` only `xsd:string`
- `observes` min 1 `Property`
- `producer` only `xsd:string`
- `propertiesStatus` only `xsd:string`
- `protocol` only `xsd:string`
- `Sensor`
- `Service`

General class axioms: +

SubClass Of (Anonymous Ancestor):

- `hasSurvivalRange` only `SurvivalRange`

Protégé: Object Properties

The screenshot displays the Protégé interface for editing an ontology. The main window is titled "Object property hierarchy: endsAtNode". On the left, a tree view shows the hierarchy of object properties, with "endsAtNode" selected. The central pane is divided into two sections: "Annotations: endsAtNode" and "Characteristics: endsAtNode".

Annotations: endsAtNode

- rdfs:label** [language: it]: Finisce al nodo
- rdfs:label** [language: en]: Ends at node
- rdfs:comment** [language: it]: Un elemento stradale è delimitato da due nodi.
- rdfs:comment** [language: en]: A road element is delimited by 2 nodes.

Characteristics: endsAtNode

- Functional
- Inverse functional
- Transitive
- Symmetric
- Asymmetric
- Reflexive
- Irreflexive

Description: endsAtNode

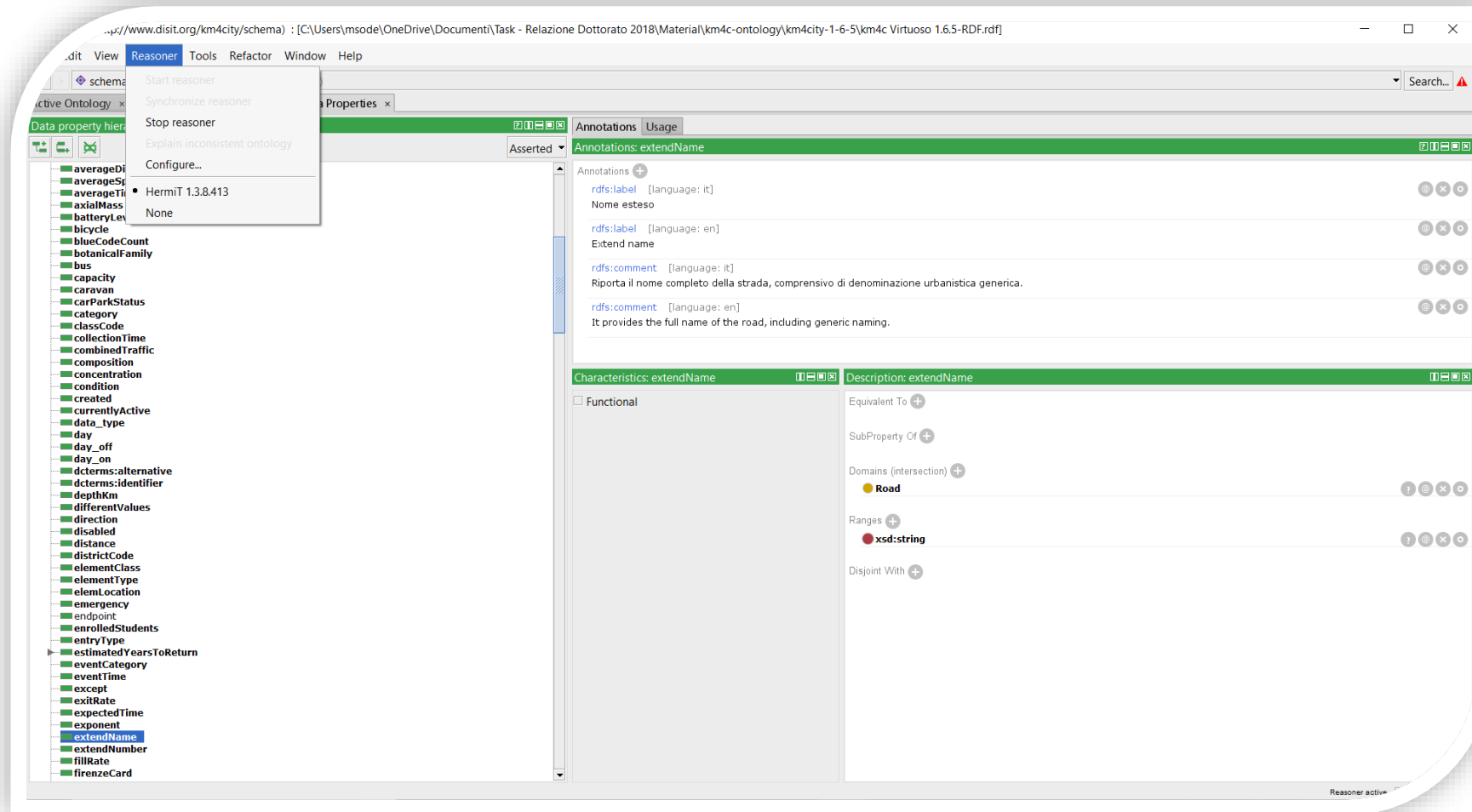
- Equivalent To: +
- SubProperty Of: +
- Inverse Of: +
- Domains (intersection): +
 - RoadElement
- Ranges (intersection): +
 - Node
- Disjoint With: +
- SuperProperty Of (Chain): +

Protégé: Data Properties

The screenshot displays the Protégé ontology editor interface. The left sidebar shows a tree view of the ontology classes, with 'extendName' selected. The main workspace is divided into several panes:

- Annotations: extendName:** This pane shows the annotations for the 'extendName' property. It includes:
 - rdfs:label [language: it]:** Nome esteso
 - rdfs:label [language: en]:** Extend name
 - rdfs:comment [language: it]:** Riporta il nome completo della strada, comprensivo di denominazione urbanistica generica.
 - rdfs:comment [language: en]:** It provides the full name of the road, including generic naming.
- Characteristics: extendName:** This pane shows the characteristics of the property, including:
 - Functional
 - Equivalent To:** (empty)
 - SubProperty Of:** (empty)
 - Domains (intersection):** A domain of 'Road' is specified.
 - Ranges:** A range of 'xsd:string' is specified.
 - Disjoint With:** (empty)

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/>

Open Graph x +
→ ↻ https://log.disit.org/service/

Linked Open Graph

Select a SPARQL endpoint: Global Endpoint Map

AEMET metereological dataset ▼

Examples: View endpoint relation

- [Observation at: 1313948400000 from: 08051 about: GEO925](#)
- [Observación: 1313948400000 de: 1639X sobre: DMAX10m](#)
- [Observación: 1313948400000 de: 08040 sobre: PREC](#)
- [Observación: 1313948400000 de: 08006 sobre: RVIENTO](#)

Choose a class:
Search for keyword ▼

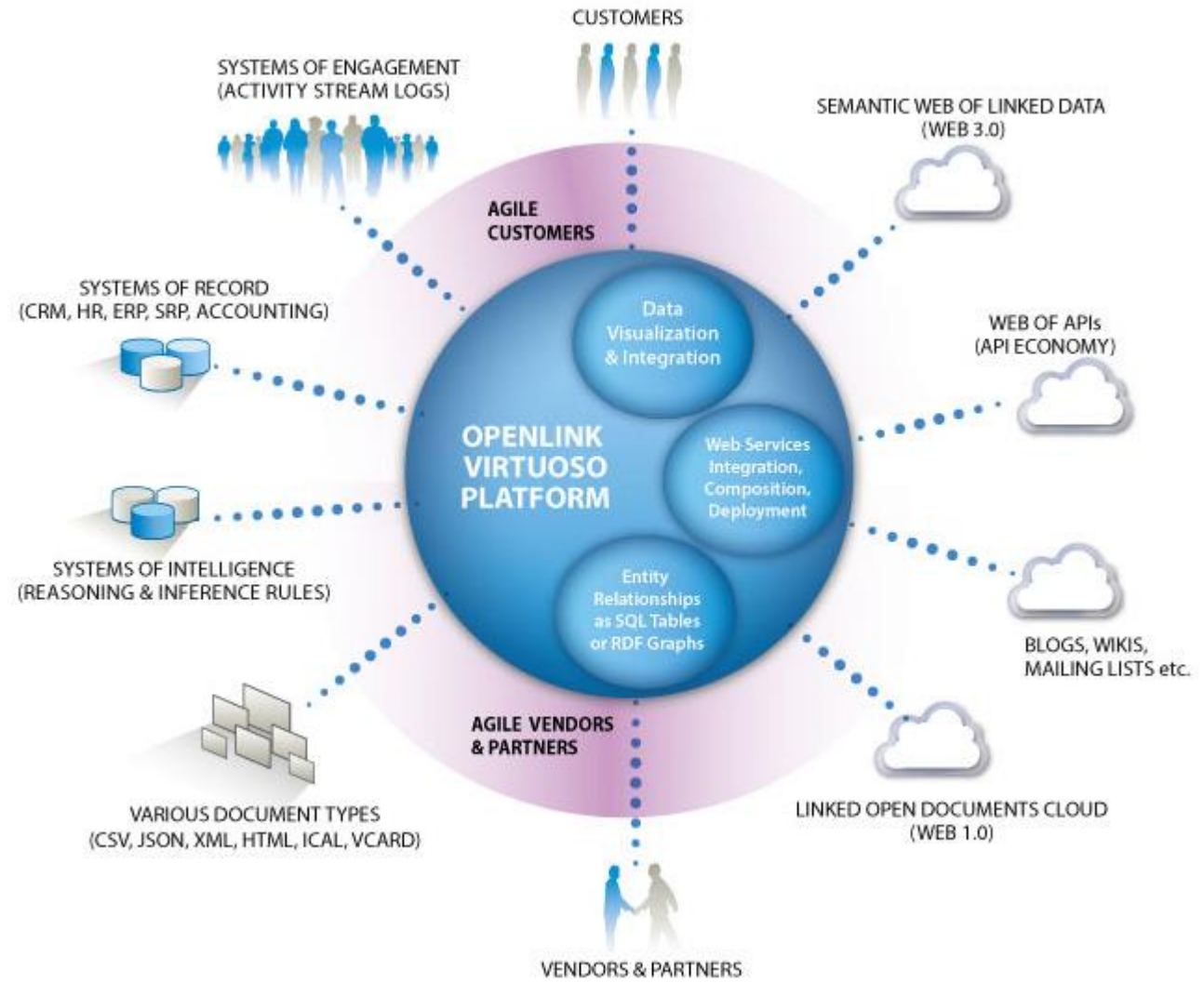
keyword:

uri: Request

Multiple endpoint search

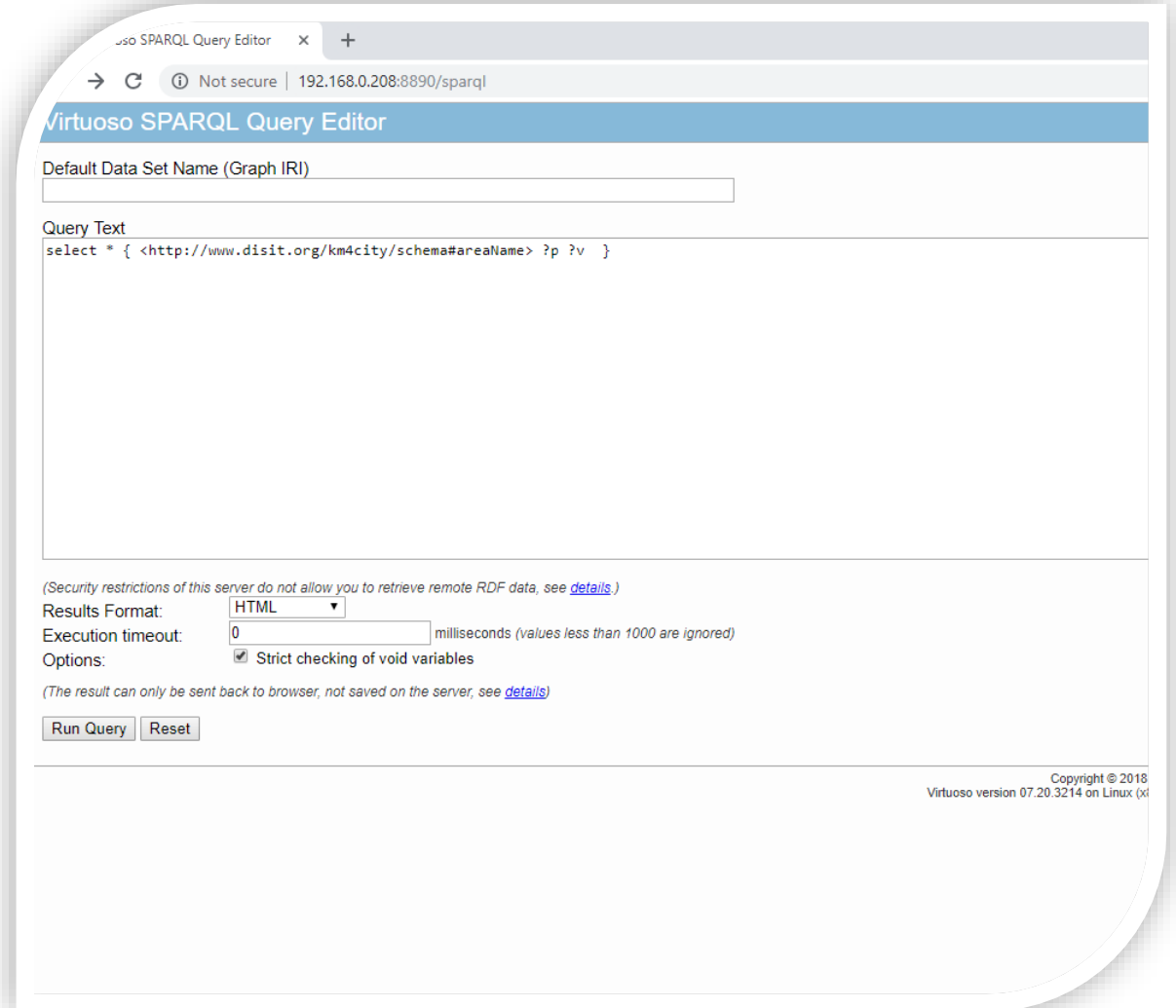
Virtuoso: Quick Introduction

- Virtuoso is an 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

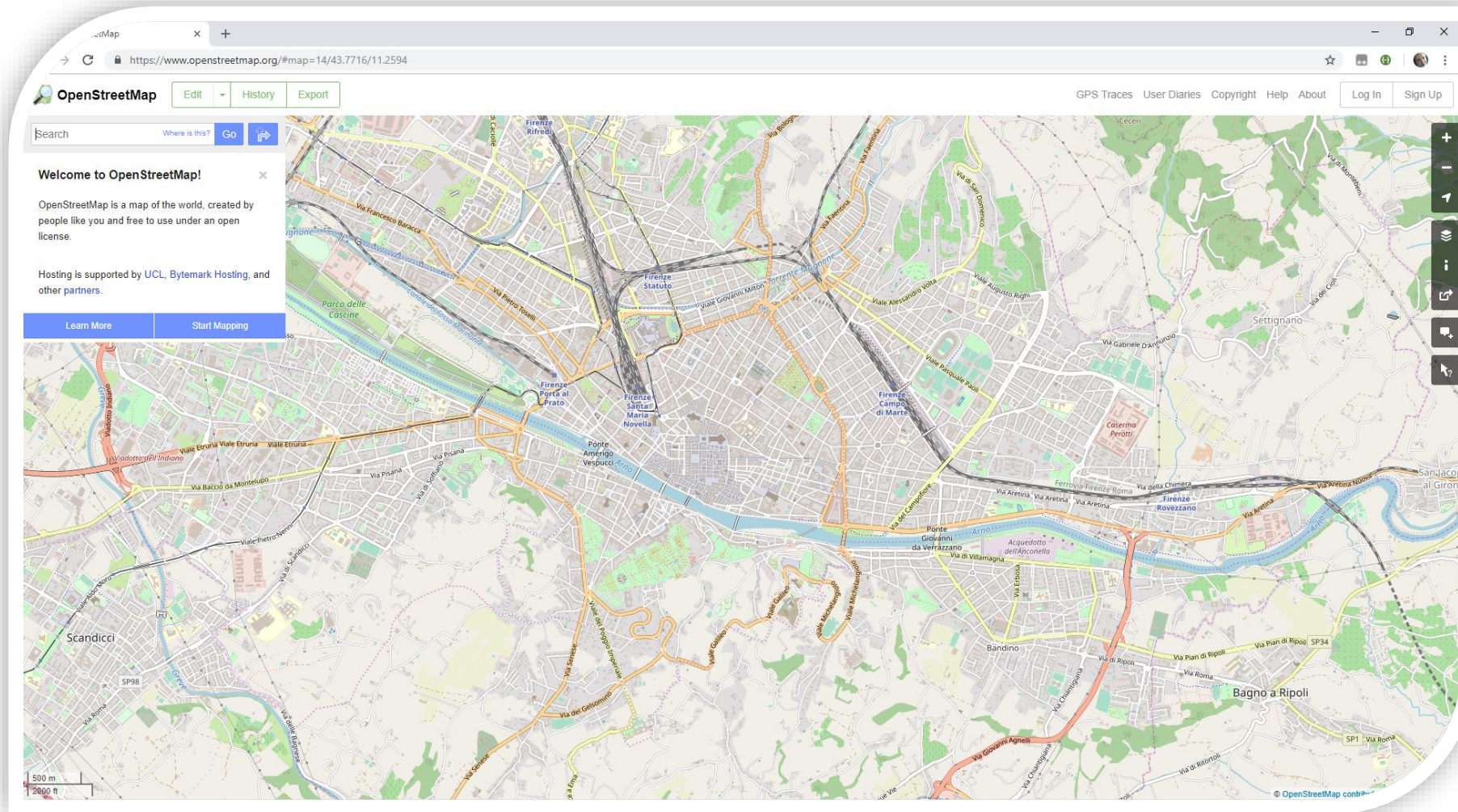
- For each Virtuoso server instance a Web interface is available for submitting SPARQL queries
- Different result formats are available



The screenshot shows a web browser window with the title "Virtuoso SPARQL Query Editor". The address bar shows "192.168.0.208:8890/sparql". The page has a blue header with the title. Below the header, there is a text input field for "Default Data Set Name (Graph IRI)". The main area is labeled "Query Text" and contains a SPARQL query: `select * { <http://www.disit.org/km4city/schema#areaName> ?p ?v }`. Below the query text, there are several settings: "Results Format" is set to "HTML", "Execution timeout" is set to "0" milliseconds, and "Options" includes a checked checkbox for "Strict checking of void variables". There are two buttons: "Run Query" and "Reset". At the bottom right, there is a copyright notice: "Copyright © 2018 Virtuoso version 07.20.3214 on Linux (x86_64)".

Open Street Map

www.openstreetmap.org



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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		<code>route_master</code> 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 <code>public_transport=stop_area</code> .	
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 <code>waterway=*</code> .	
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, ...)



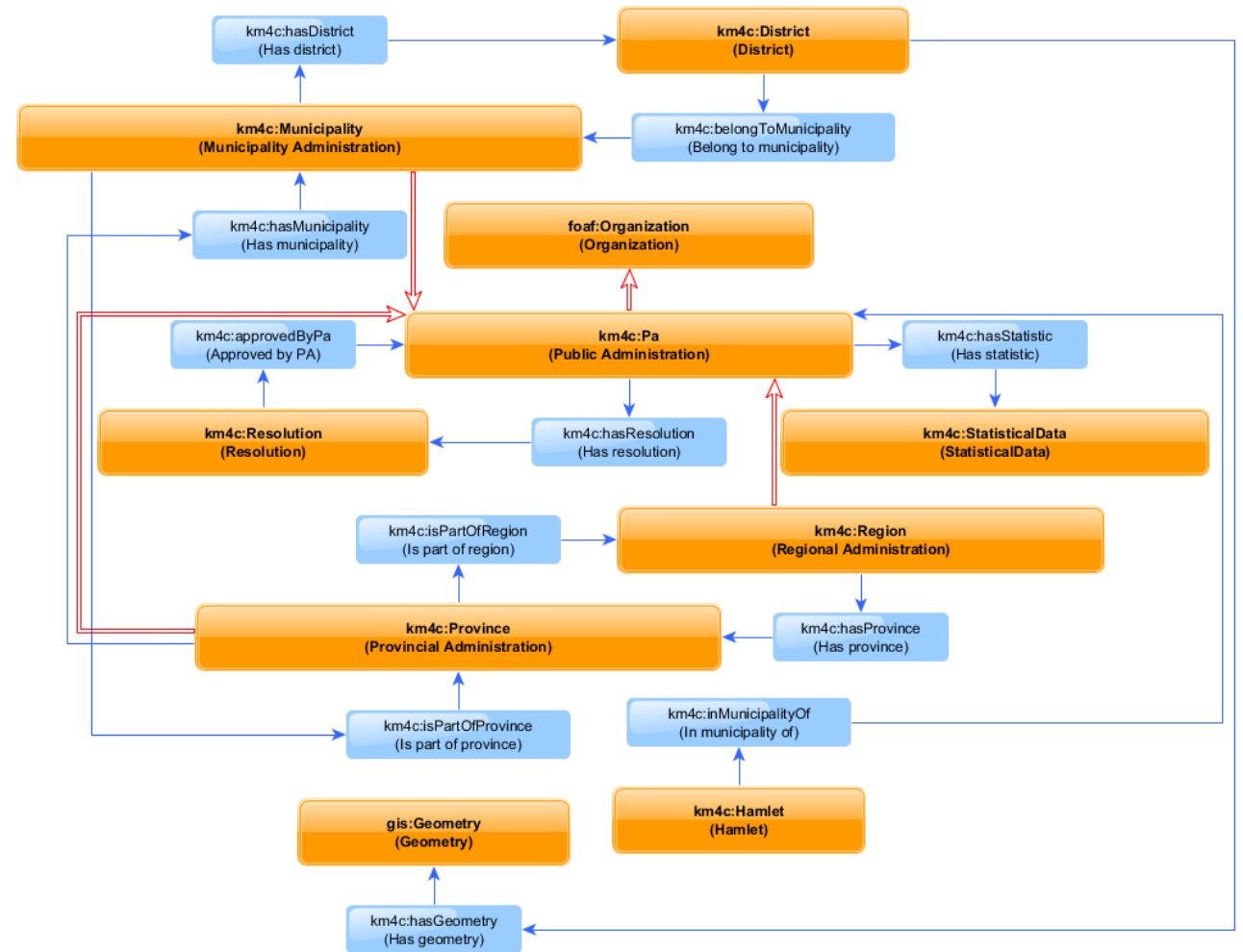
Km4City Ontology

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

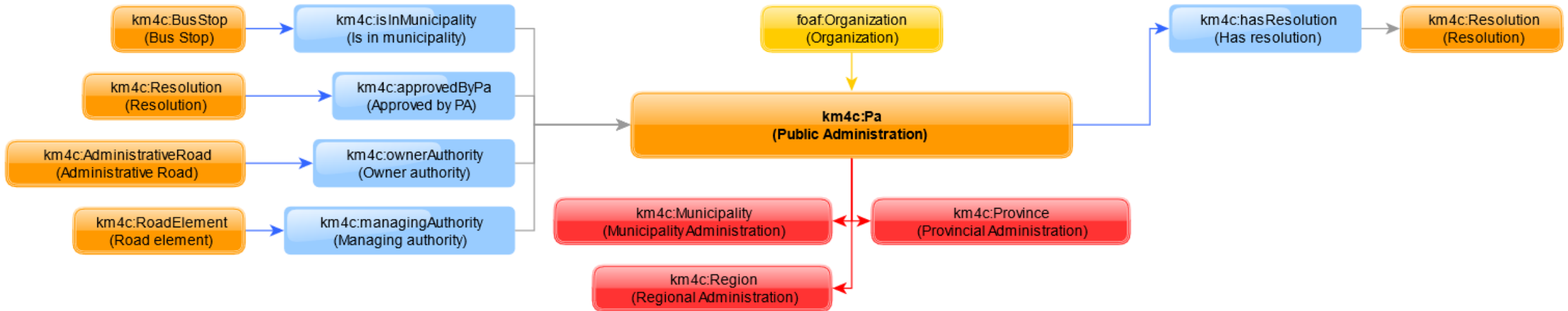


Km4City Ontology: Public Administration

- 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

The screenshot displays the Protégé application window with the 'Object Properties' tab selected. The left pane shows a tree view of object properties, with 'inMunicipalityOf' highlighted. The right pane is divided into three sections: 'Annotations', 'Characteristics', and 'Description'. The 'Annotations' section shows three entries: an Italian label 'Nel comune', an English label 'In municipality of', and two comments in Italian and English. The 'Characteristics' section lists various property characteristics, all of which are unchecked. The 'Description' section shows that the property is 'Equivalent To' 'Hamlet or Road' and has a 'Domain' of '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**

The screenshot shows the Protégé Search window with the search term 'Pa' entered. The search options are: Case sensitive (unchecked), Whole words (unchecked), Ignore white space (checked), Regular expression (unchecked), Show all results (checked), Search in IRIs (checked), Search in annotation values (checked), and Search in logical axioms (checked). The search results are displayed in a table with three columns: Found in, Entity, and Match. The 'inMunicipalityOf' property is highlighted in blue.

Found in	Entity	Match
ObjectPropertyRange	schema:parents	schema:parents Range schema:Person
	schema:partOfEpisode	schema:partOfEpisode Range schema:Episode
	schema:partOfOrder	schema:partOfOrder Range schema:Order
ObjectPropertyRange	schema:partOfSeason	schema:partOfSeason Range schema:Season
	schema:partOfSeries	schema:partOfSeries Range schema:Series
	schema:partOfSystem	schema:partOfSystem Range schema:AnatomicalSystem
ObjectPropertyRange	schema:partOfTVSeries	schema:partOfTVSeries Range schema:TVSeries
	schema:participant	schema:participant Range schema:Organization
	schema:paymentDue	schema:paymentDue Range schema:DateTime
	schema:paymentMethod	schema:paymentMethod Range schema:PaymentMethod
	schema:paymentUrl	schema:paymentUrl Range rdfs:Resource
	inMunicipalityOf	inMunicipalityOf Range Pa
	schema:spatial	schema:spatial Range schema:Place
	hasMunicipality	hasMunicipality Range Municipality
	schema:department	schema:department Range schema:Organization
	schema:isPartOf	schema:isPartOf Range schema:CollectionPage
	approvedByPa	approvedByPa Range Pa
	isInMunicipality	isInMunicipality Range Pa
	observeCarPark	observeCarPark Range TransferServiceAndRent
	belongToMunicipality	belongToMunicipality Range Municipality
	refersToMunicipality	refersToMunicipality Range Municipality
	schema:acceptedPaymentMethod	schema:acceptedPaymentMethod Range schema:PaymentMethod
	schema:appliesToPaymentMethod	schema:appliesToPaymentMethod Range schema:PaymentMethod
	schema:mainContentOfPage	schema:mainContentOfPage Range schema:WebPage

Copy selected entities

Protégé: Browsing Properties (3)

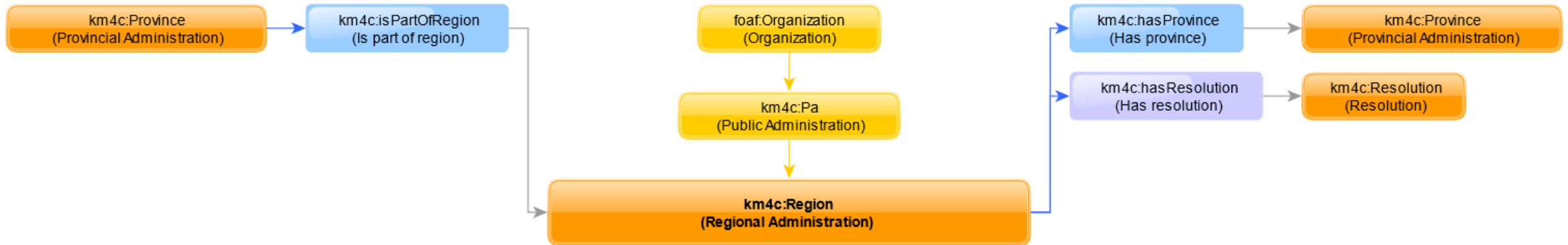
- The same way, searching for **Pa** and browsing to the **ObjectPropertyDomain** category of results, you will discover that resources of type **Pa** can have the **hasResolution** property.

The screenshot shows the Protégé search window with the search term 'Pa'. The search options are: Case sensitive (unchecked), Whole words (unchecked), Ignore white space (checked), Regular expression (unchecked), Show all results (checked), Search in IRIs (checked), Search in annotation values (checked), and Search in logical axioms (checked). The search results are displayed in a table with three columns: Found in, Entity, and Match. The 'ObjectPropertyDomain' category is selected, and the 'hasResolution' property is highlighted in blue. The match for 'hasResolution' is 'hasResolution Domain Pa'.

Found in	Entity	Match
ObjectPropertyDomain	approvedByPa	approvedByPa Domain Resolution
	isInMunicipality	isInMunicipality Domain BusStop
	observeCarPark	observeCarPark Domain CarParkSensor
	schema:preparation	schema:preparation Domain schema:MedicalPro
	schema:occupationalCategory	schema:occupationalCategory Domain schema:.
	schema:printPage	schema:printPage Domain schema:NewsArticle
	belongToMunicipality	belongToMunicipality Domain District
	refersToMunicipality	refersToMunicipality Domain WeatherReport
	schema:acceptedPaymentMet	schema:acceptedPaymentMethod Domain scher
	schema:appliesToPaymentMe	schema:appliesToPaymentMethod Domain sche
	schema:associatedPathophys	schema:associatedPathophysiology Domain sch
	hasRecord	hasRecord Domain CarParkSensor
	hasStatistic	hasStatistic Domain Pa or Road
	schema:mainContentOfPage	schema:mainContentOfPage Domain schema:W
	schema:productionCompany	schema:productionCompany Domain schema:Et
	hasResolution	hasResolution Domain Pa
	schema:isAccessoryOrSpareF	schema:isAccessoryOrSparePartFor Domain sch
	schema:primaryImageOfPage	schema:primaryImageOfPage Domain schema:v
	hasDistrict	hasDistrict Domain Municipality
	schema:carrier	schema:carrier Domain schema:ParcelDelivery
	hasWeatherReport	hasWeatherReport Domain Municipality
	schema:childMaxAge	schema:childMaxAge Domain schema:ParentAuc
	schema:childMinAge	schema:childMinAge Domain schema:ParentAuc
	schema:itemShipped	schema:itemShipped Domain schema:ParcelDel

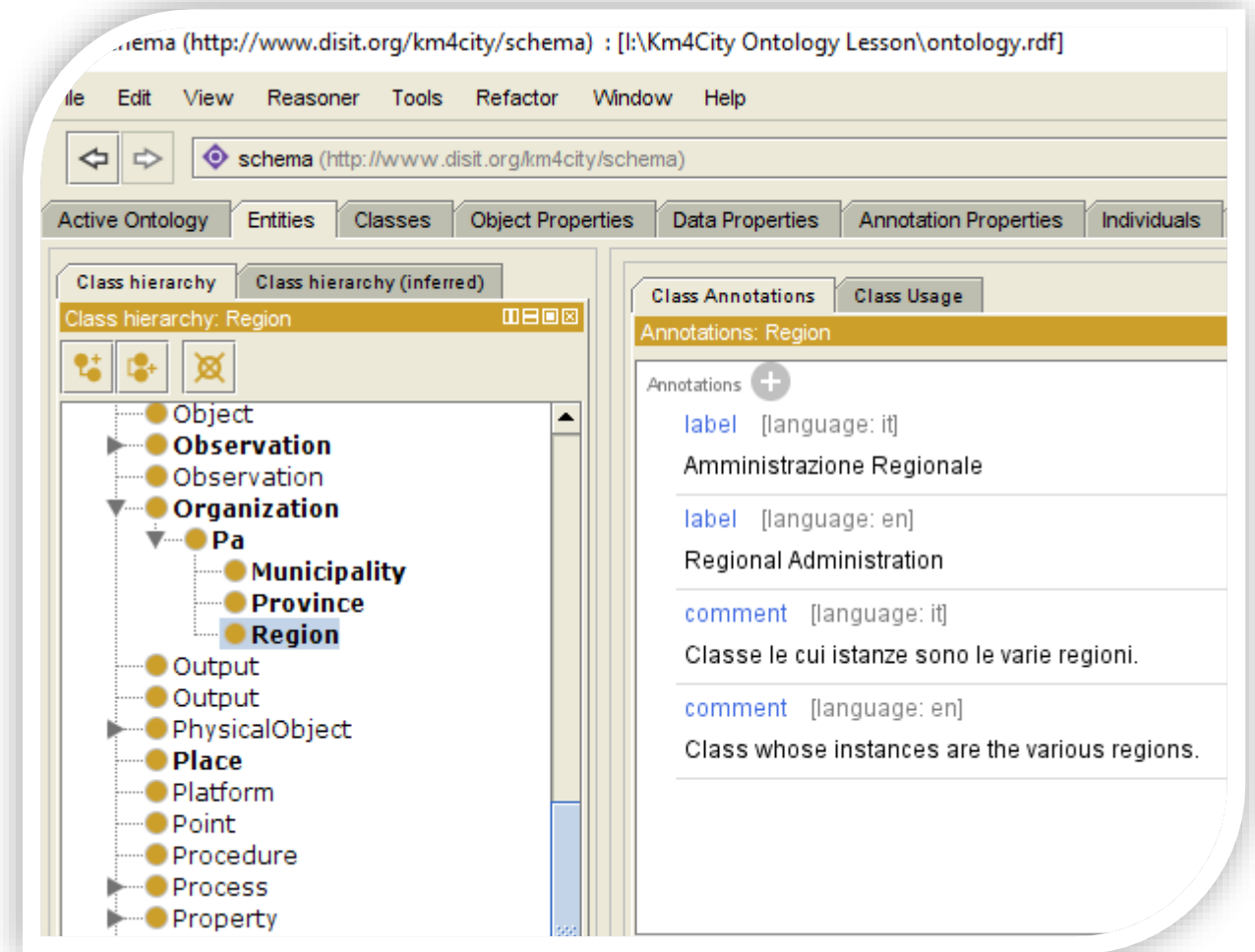
Copy selected entities

Km4City Ontology: Region



Protégé: Class Meta & Relations

- Let's see how labels, comments, and other metadata about a class, are represented in:
 - **Protégé**
 - 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

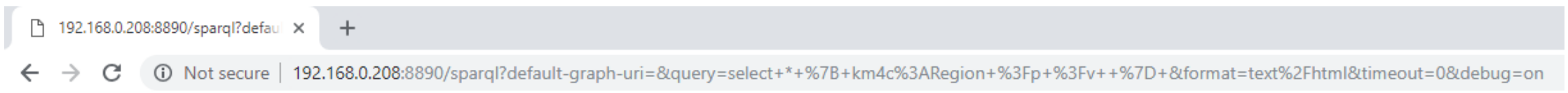
```
<!-- http://www.disit.org/km4city/schema#Region -->  
  
<Class rdf:about="&km4c;Region">  
  <rdfs:label xml:lang="en">Regional Administration</rdfs:label>  
  <rdfs:label xml:lang="it">Amministrazione Regionale</rdfs:label>  
  <rdfs:subClassOf rdf:resource="&km4c;Pa"/>  
  <rdfs:comment xml:lang="en">Class 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



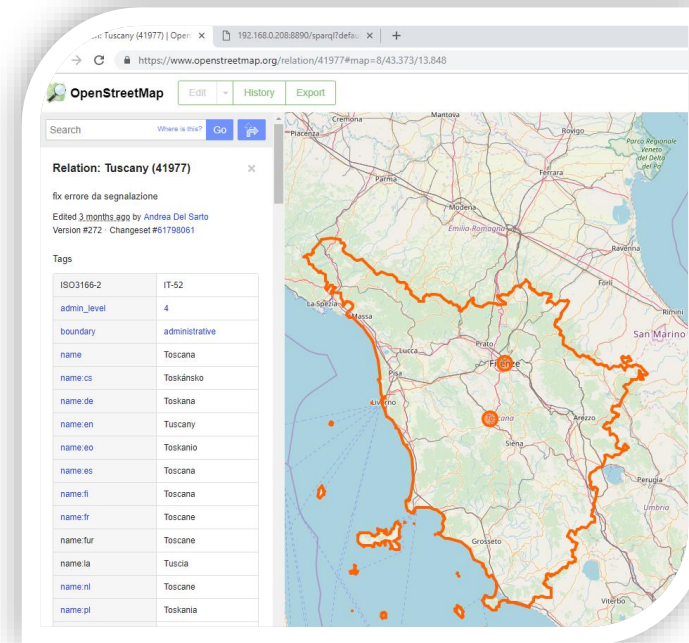
Region *Resource*: Km4City KB vs OSM

Km4City KB

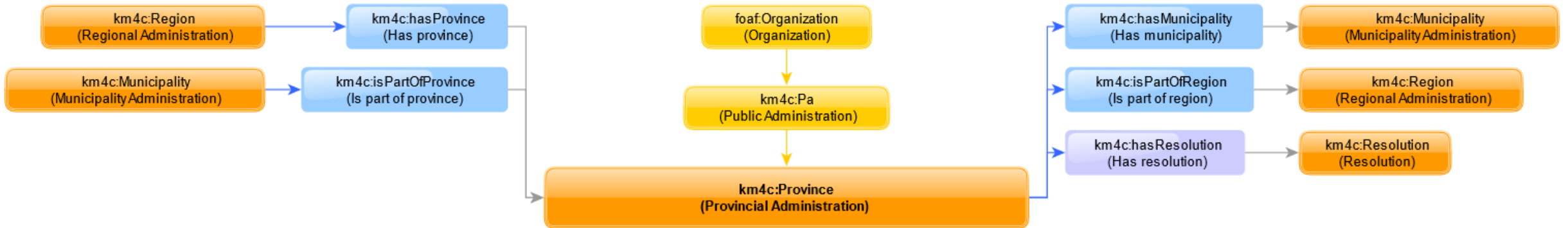
- ```
select * {
 ?s a km4c:Region;
 foaf:name "Toscana";
 ?p ?v
}
```
- [http://192.168.0.208:8890/sparql?default-graph-uri=&query=select+\\*+%7B+%3Fs+a+km4c%3ARegion%3B+foaf%3Aname+%22Toscana%22%3B+%3Fp+%3Fv+%7D+%&format=text%2Fhtml&timeout=0&debug=on](http://192.168.0.208:8890/sparql?default-graph-uri=&query=select+*+%7B+%3Fs+a+km4c%3ARegion%3B+foaf%3Aname+%22Toscana%22%3B+%3Fp+%3Fv+%7D+%&format=text%2Fhtml&timeout=0&debug=on)
- <http://www.disit.org/km4city/resource/OS00000041977RG>

## 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`

The screenshot shows the Protégé ontology editor interface. The main window displays the 'Object property hierarchy: hasResolution' tree on the left, with 'hasResolution' selected. The right pane shows the 'Annotations: hasResolution' and 'Description: hasResolution' sections. The 'Annotations' section lists three annotations: a label in Italian 'Ha delibera', a label in English 'Has resolution', and a comment in Italian 'Collega una delibera all'ebte che la ha approvata.' The 'Description' section shows the property is 'Equivalent To' 'approvedByPa' and has a domain of 'Pa' and a range of 'Resolution'. The 'Characteristics' section shows the property is not functional, inverse functional, transitive, symmetric, asymmetric, reflexive, or irreflexive.

# XML/RDF: Object Properties

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

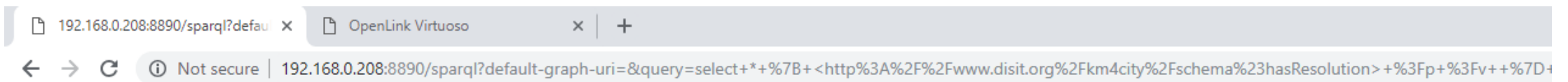
<ObjectProperty rdf:about="&km4c;hasResolution">
 <rdfs:label xml:lang="en">Has resolution</rdfs:label>
 <rdfs:label xml:lang="it">Ha delibera</rdfs:label>
 <rdfs:comment xml:lang="en">To connect a resolution to the municipality that have approved it.</rdfs:comment>
 <rdfs:comment xml:lang="it">Collega 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
<a href="http://www.w3.org/1999/02/22-rdf-syntax-ns#type">http://www.w3.org/1999/02/22-rdf-syntax-ns#type</a>	<a href="http://www.w3.org/2002/07/owl#ObjectProperty">http://www.w3.org/2002/07/owl#ObjectProperty</a>
<a href="http://www.w3.org/2000/01/rdf-schema#label">http://www.w3.org/2000/01/rdf-schema#label</a>	"Ha delibera"@it
<a href="http://www.w3.org/2000/01/rdf-schema#label">http://www.w3.org/2000/01/rdf-schema#label</a>	"Has resolution"@en
<a href="http://www.w3.org/2000/01/rdf-schema#domain">http://www.w3.org/2000/01/rdf-schema#domain</a>	<a href="http://www.disit.org/km4city/schema#Pa">http://www.disit.org/km4city/schema#Pa</a>
<a href="http://www.w3.org/2000/01/rdf-schema#range">http://www.w3.org/2000/01/rdf-schema#range</a>	<a href="http://www.disit.org/km4city/schema#Resolution">http://www.disit.org/km4city/schema#Resolution</a>
<a href="http://www.w3.org/2000/01/rdf-schema#comment">http://www.w3.org/2000/01/rdf-schema#comment</a>	"Collega una delibera all'ebte che la ha approvata."@it
<a href="http://www.w3.org/2000/01/rdf-schema#comment">http://www.w3.org/2000/01/rdf-schema#comment</a>	"To connect a resolution to the municipality that have approved it."@en



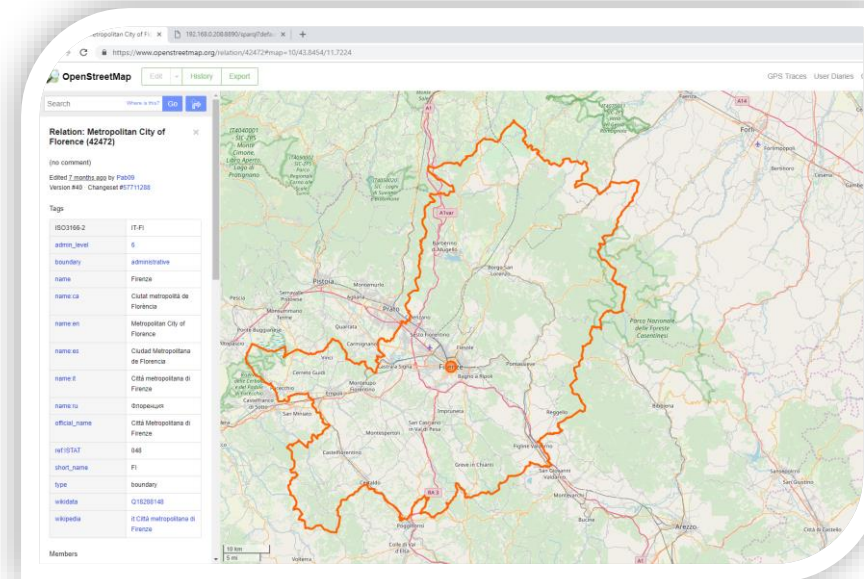
# Province *Resource*: Km4City KB vs OSM

## Km4City KB

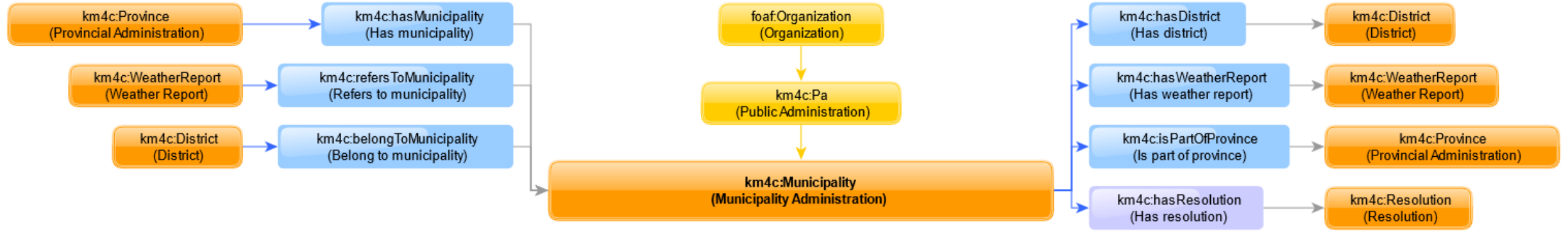
- ```
select * {  
  ?s a km4c:Province;  
  foaf:name "Firenze";  
  ?p ?v  
}
```
- http://192.168.0.208:8890/sparql?default-graph-uri=&query=select+*+%7B+%3Fs+a+km4c%3AProvince%3B+foaf%3Aname+%22Firenze%22%3B+%3Fp+%3Fv+%7D+%&format=text%2Fhtml&timeout=0&debug=on
- <http://www.disit.org/km4city/resource/OS00000042472PR>

Open Street Map

- <https://www.openstreetmap.org/relation/42472>



Km4City Ontology: Municipality



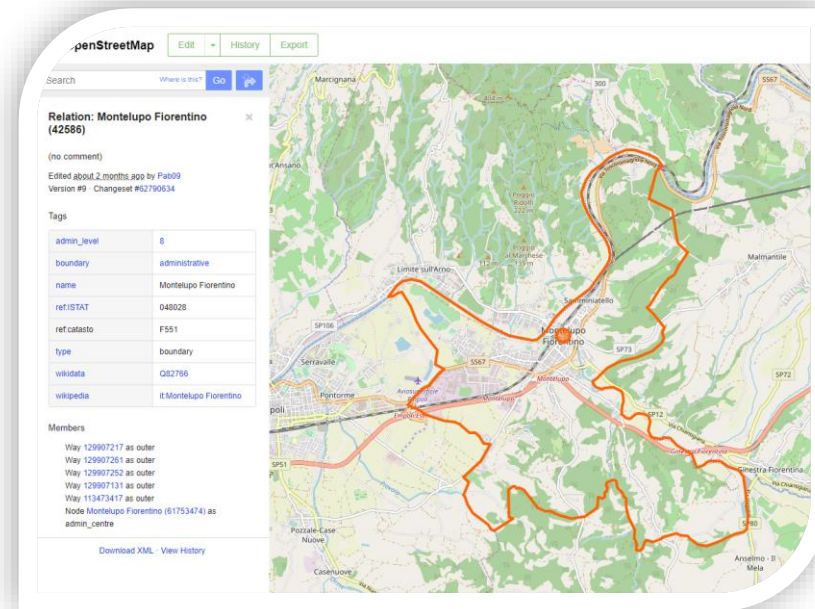
Municipality *Resource*: Km4City KB vs OSM

Km4City KB

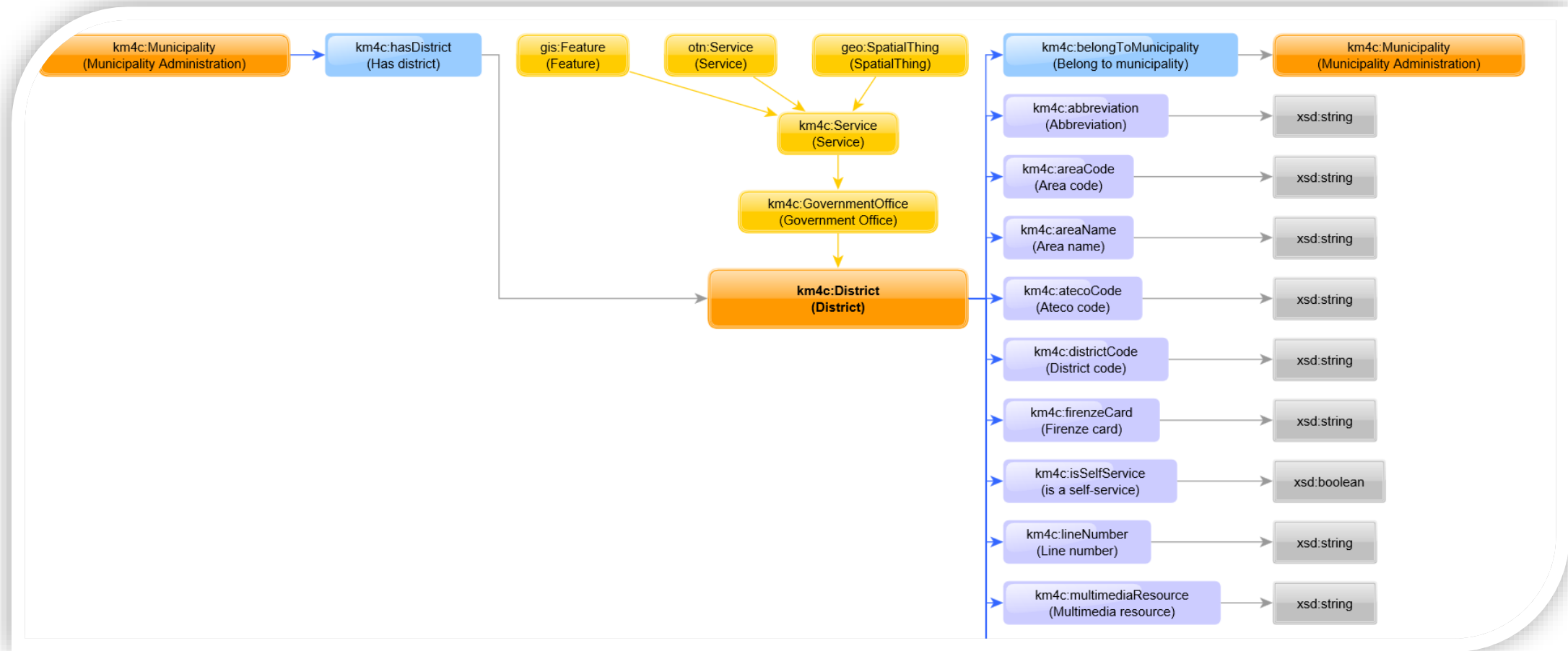
- ```
select * {
 ?s a km4c:Municipality;
 foaf:name "Montelupo Fiorentino";
 ?p ?v
}
```
- [http://192.168.0.208:8890/sparql?default-graph-uri=&query=select+\\*+%7B+%3Fs+a+km4c%3AMunicipality%3B+foaf%3Aname+%22Montelupo+Fiorentino%22%3B+%3Fp+%3Fv+%7D+%&format=text%2Fhtml&timeout=0&debug=on](http://192.168.0.208:8890/sparql?default-graph-uri=&query=select+*+%7B+%3Fs+a+km4c%3AMunicipality%3B+foaf%3Aname+%22Montelupo+Fiorentino%22%3B+%3Fp+%3Fv+%7D+%&format=text%2Fhtml&timeout=0&debug=on)
- <http://www.disit.org/km4city/resource/OS00000042586CO>

## 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

The screenshot displays the Protégé interface for editing the 'areaName' data property. The left pane shows a tree view of data properties, with 'areaName' selected. The right pane shows the 'Annotations' and 'Description' panels. The 'Annotations' panel lists labels in Italian and English, and comments in Italian and English. The 'Description' panel shows the property is functional, equivalent to 'Service', and has a range of 'xsd:string'.

# XML/RDF: Data Properties

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

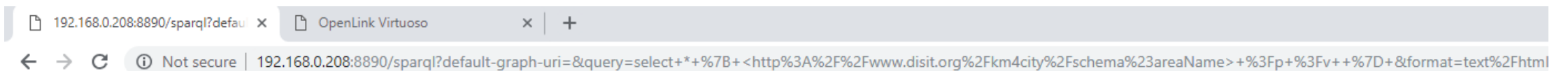
<DatatypeProperty rdf:about="&km4c;areaName">
 <rdfs:label xml:lang="en">Area name</rdfs:label>
 <rdfs:label xml:lang="it">Nome area</rdfs:label>
 <rdfs:comment xml:lang="en">Name of the area, defined at the municipal level, where the service or the sensor is located.</rdfs:comment>
 <rdfs:comment xml:lang="it">Nome dell'area, definita a livello comunale, all'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 }
```

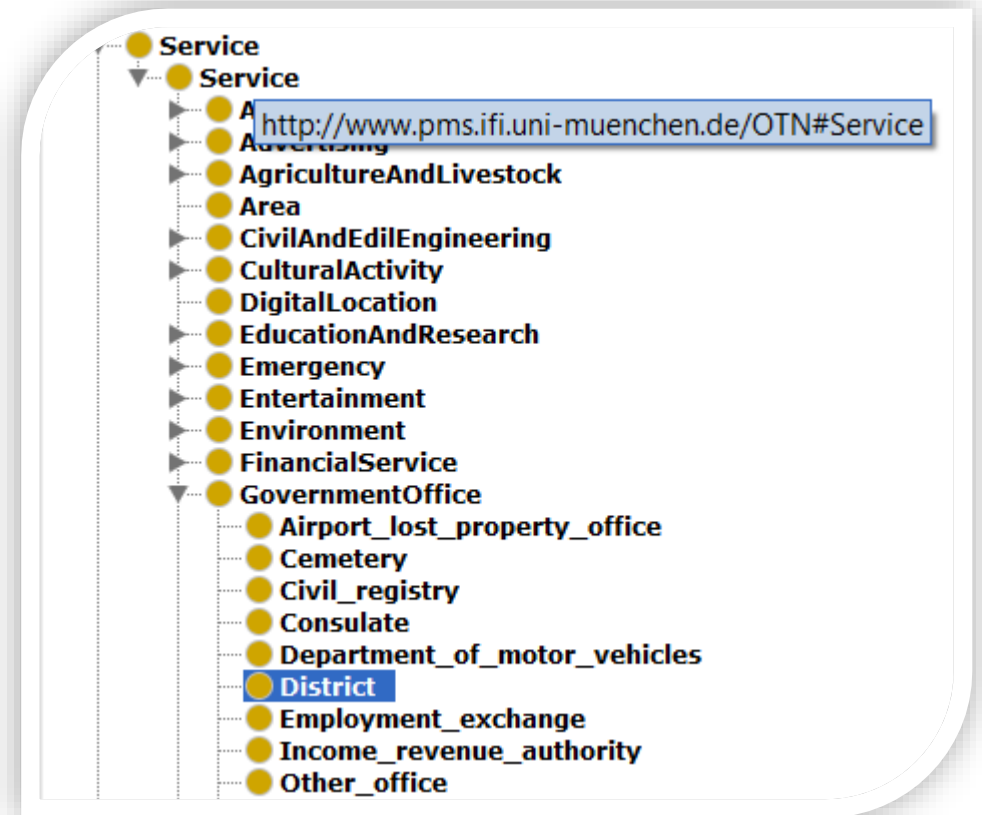
```
select * { <http://www.disit.org/km4city/schema#areaName> ?p ?v }
```



p	v
<a href="http://www.w3.org/1999/02/22-rdf-syntax-ns#type">http://www.w3.org/1999/02/22-rdf-syntax-ns#type</a>	<a href="http://www.w3.org/2002/07/owl#DatatypeProperty">http://www.w3.org/2002/07/owl#DatatypeProperty</a>
<a href="http://www.w3.org/2000/01/rdf-schema#label">http://www.w3.org/2000/01/rdf-schema#label</a>	"Area name"@en
<a href="http://www.w3.org/2000/01/rdf-schema#label">http://www.w3.org/2000/01/rdf-schema#label</a>	"Nome area"@it
<a href="http://www.w3.org/2000/01/rdf-schema#domain">http://www.w3.org/2000/01/rdf-schema#domain</a>	<a href="http://www.disit.org/km4city/schema#Service">http://www.disit.org/km4city/schema#Service</a>
<a href="http://www.w3.org/2000/01/rdf-schema#range">http://www.w3.org/2000/01/rdf-schema#range</a>	<a href="http://www.w3.org/2001/XMLSchema#string">http://www.w3.org/2001/XMLSchema#string</a>
<a href="http://www.w3.org/2000/01/rdf-schema#comment">http://www.w3.org/2000/01/rdf-schema#comment</a>	"Name of the area, defined at the municipal level, where the service or the sensor is located."@en
<a href="http://www.w3.org/2000/01/rdf-schema#comment">http://www.w3.org/2000/01/rdf-schema#comment</a>	"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

The screenshot shows the Protégé interface with the 'Active Ontology' tab selected. The 'Ontology header' section displays the following information:

- Ontology IRI:** <http://www.disit.org/km4city/schema>
- Ontology Version IRI:** e.g. <http://www.disit.org/km4city/schema/1.0.0>

The 'Annotations' section shows the following properties:

- preferredNamespacePrefix:** km4c
- title:** [language: en] km4city, the DISIT Knowledge Model for City and Mobility
- preferredNamespaceUri:** <http://www.disit.org/km4city/schema>
- label:** [language: en] km4city: the DISIT Knowledge Model for City and Mobility
- rights:** [language: en]

The 'Ontology Prefixes' tab is also visible, showing a table of prefixes and their corresponding URIs:

Prefix	URI
	<a href="http://www.w3.org/2002/07/owl#">http://www.w3.org/2002/07/owl#</a>
cc	<a href="http://creativecommons.org/ns#">http://creativecommons.org/ns#</a>
dc	<a href="http://purl.org/dc/elements/1.1/">http://purl.org/dc/elements/1.1/</a>
dct	<a href="http://purl.org/dc/terms/">http://purl.org/dc/terms/</a>
foaf	<a href="http://xmlns.com/foaf/0.1/">http://xmlns.com/foaf/0.1/</a>
geo	<a href="http://www.w3.org/2003/01/geo/wgs84_pos#">http://www.w3.org/2003/01/geo/wgs84_pos#</a>
gis	<a href="http://www.opengis.net/ont/geosparq#">http://www.opengis.net/ont/geosparq#</a>
gr	<a href="http://purl.org/goodrelations/v1#">http://purl.org/goodrelations/v1#</a>
idt-lite	<a href="http://purl.oclc.org/NET/UNIS/ifiware/iot-lite#">http://purl.oclc.org/NET/UNIS/ifiware/iot-lite#</a>
km4c	<a href="http://www.disit.org/km4city/schema#">http://www.disit.org/km4city/schema#</a>
km4cr	<a href="http://www.disit.org/km4city/resource#">http://www.disit.org/km4city/resource#</a>
org	<a href="http://www.w3.org/ns/org#">http://www.w3.org/ns/org#</a>
otn	<a href="http://www.pms.ifi.uni-muenchen.de/OTN#">http://www.pms.ifi.uni-muenchen.de/OTN#</a>
owl	<a href="http://www.w3.org/2002/07/owl#">http://www.w3.org/2002/07/owl#</a>
rdf	<a href="http://www.w3.org/1999/02/22-rdf-syntax-ns#">http://www.w3.org/1999/02/22-rdf-syntax-ns#</a>

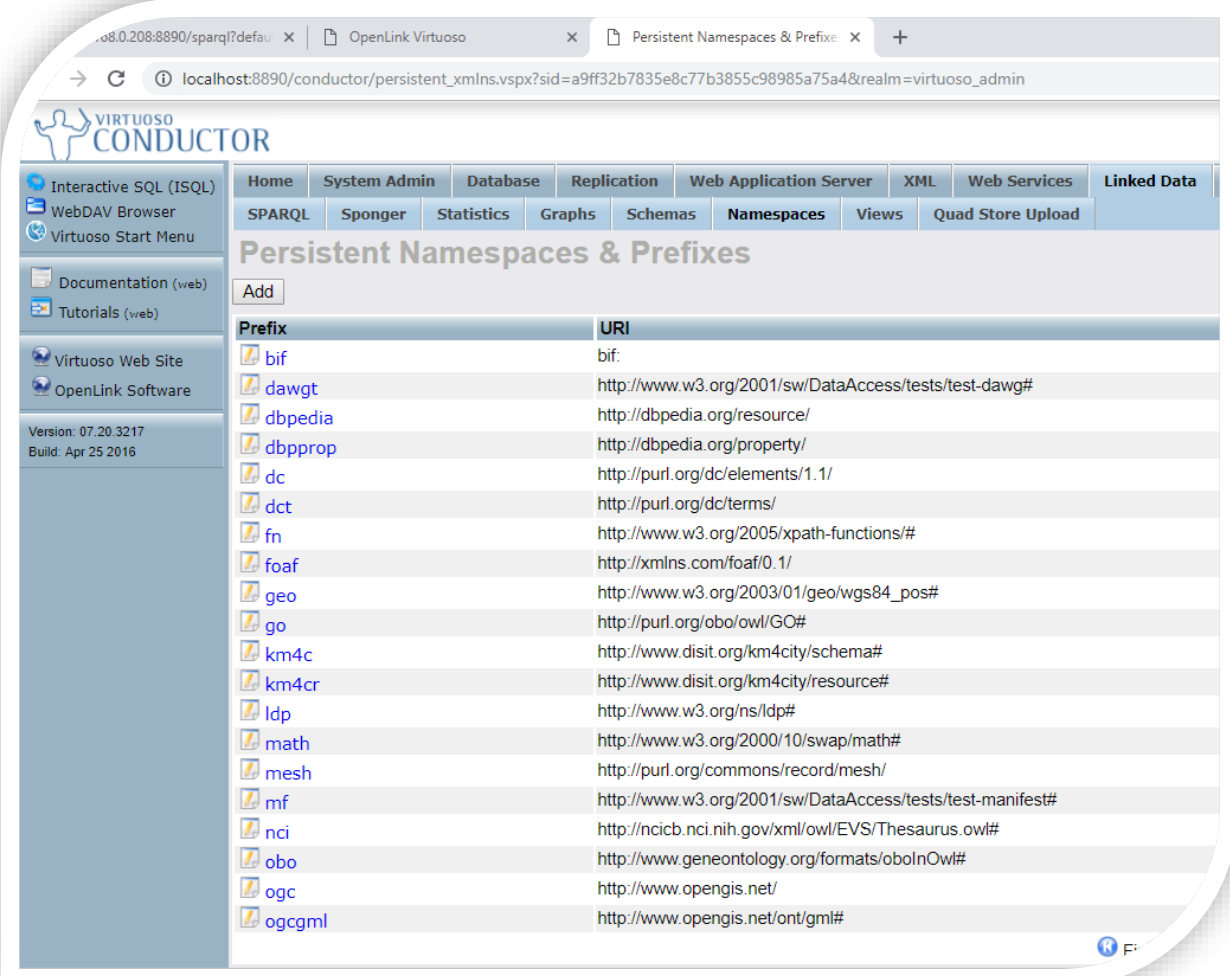


# RDF/XML: Vocabularies, and Prefixes

```
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: Vocabars, 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



The screenshot shows the Virtuoso Conductor web interface. The main content area is titled "Persistent Namespaces & Prefixes" and contains a table with two columns: "Prefix" and "URI". The table lists various prefixes and their corresponding URIs. The interface also includes a navigation menu at the top and a sidebar on the left with links to documentation and tutorials.

Prefix	URI
bif	bif.
dawgt	http://www.w3.org/2001/sw/DataAccess/tests/test-dawg#
dbpedia	http://dbpedia.org/resource/
dbpprop	http://dbpedia.org/property/
dc	http://purl.org/dc/elements/1.1/
dct	http://purl.org/dc/terms/
fn	http://www.w3.org/2005/xpath-functions/#
foaf	http://xmlns.com/foaf/0.1/
geo	http://www.w3.org/2003/01/geo/wgs84_pos#
go	http://purl.org/obo/owl/GO#
km4c	http://www.disit.org/km4city/schema#
km4cr	http://www.disit.org/km4city/resource#
ldp	http://www.w3.org/ns/ldp#
math	http://www.w3.org/2000/10/swap/math#
mesh	http://purl.org/commons/record/mesh/
mf	http://www.w3.org/2001/sw/DataAccess/tests/test-manifest#
nci	http://ncicb.nci.nih.gov/xml/owl/EVS/Thesaurus.owl#
obo	http://www.geneontology.org/formats/obolOwl#
ogc	http://www.opengis.net/
ogcgm1	http://www.opengis.net/ont/gml#

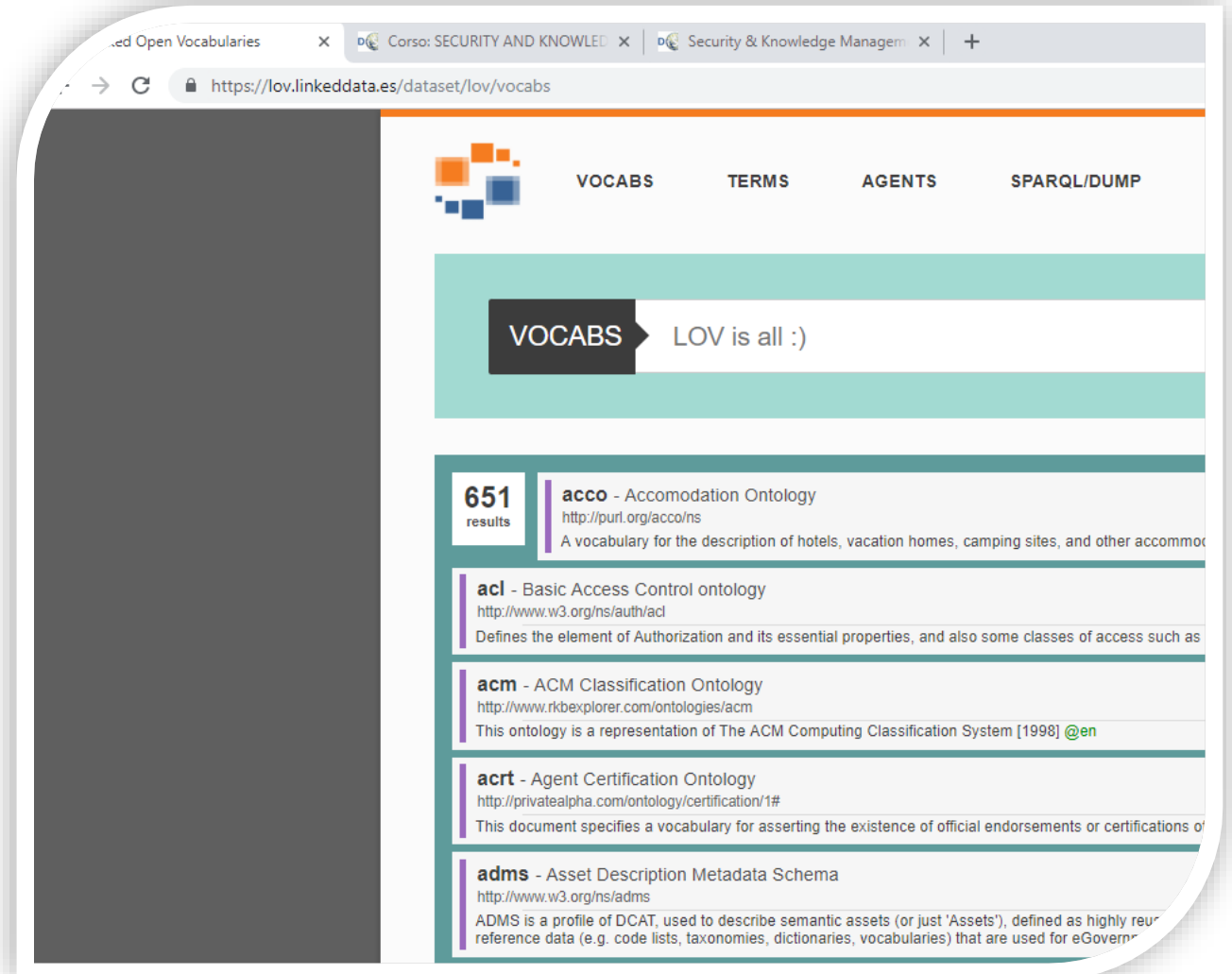
# Vocabularies: How to Learn More

- 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>

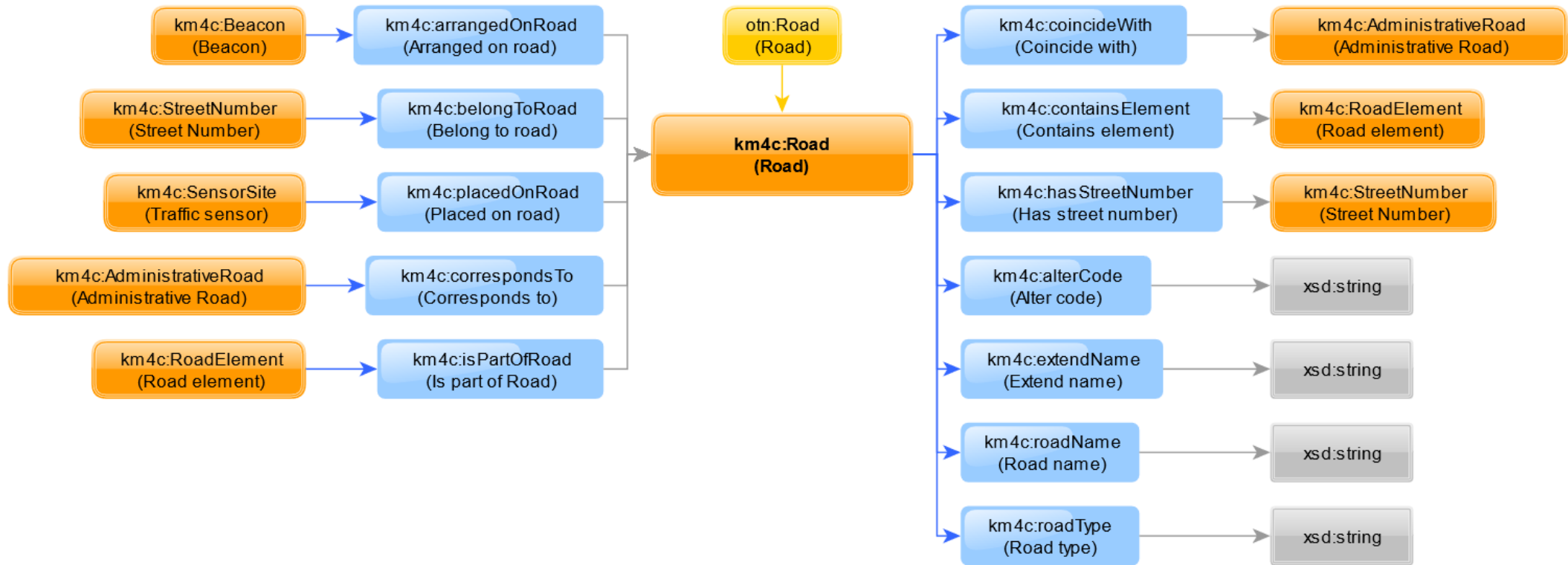


The screenshot shows a web browser window with the URL <https://lov.linkeddata.es/dataset/lov/vocabs>. The page features a navigation menu with links for VOCABS, TERMS, AGENTS, and SPARQL/DUMP. A prominent banner displays 'VOCABS' with a right-pointing arrow and the text 'LOV is all :)'. Below this, a list of search results is shown, each with a purple vertical bar on the left. The results include:

- 651 results**
- acco** - Accomodation Ontology  
<http://purl.org/acco/ns>  
A vocabulary for the description of hotels, vacation homes, camping sites, and other accommo
- acl** - Basic Access Control ontology  
<http://www.w3.org/ns/auth/acl>  
Defines the element of Authorization and its essential properties, and also some classes of access such as
- acm** - ACM Classification Ontology  
<http://www.rkbexplorer.com/ontologies/acm>  
This ontology is a representation of The ACM Computing Classification System [1998] @en
- acrt** - Agent Certification Ontology  
<http://privatealpha.com/ontology/certification/1#>  
This document specifies a vocabulary for asserting the existence of official endorsements or certifications of
- adms** - Asset Description Metadata Schema  
<http://www.w3.org/ns/adms>  
ADMS is a profile of DCAT, used to describe semantic assets (or just 'Assets'), defined as highly reusable reference data (e.g. code lists, taxonomies, dictionaries, vocabularies) that are used for eGovern

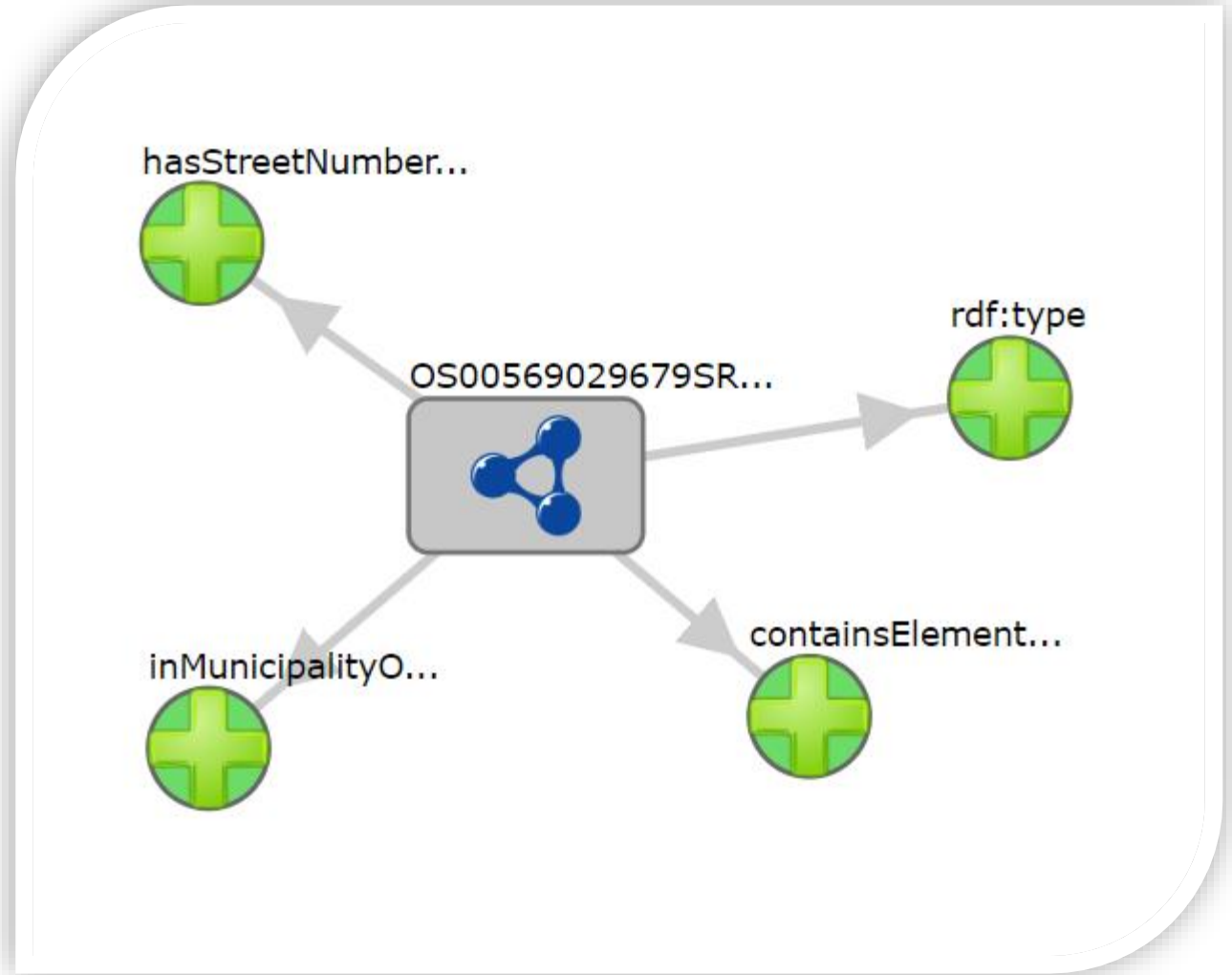


# Km4City Ontology: Road



# 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
}
```

<b>p</b>
<a href="http://www.disit.org/km4city/schema#hasStreetNumber">http://www.disit.org/km4city/schema#hasStreetNumber</a>
<a href="http://www.disit.org/km4city/schema#containsElement">http://www.disit.org/km4city/schema#containsElement</a>
<a href="http://www.w3.org/1999/02/22-rdf-syntax-ns#type">http://www.w3.org/1999/02/22-rdf-syntax-ns#type</a>
<a href="http://www.disit.org/km4city/schema#inMunicipalityOf">http://www.disit.org/km4city/schema#inMunicipalityOf</a>



# Road Resource: Km4City KB vs OSM

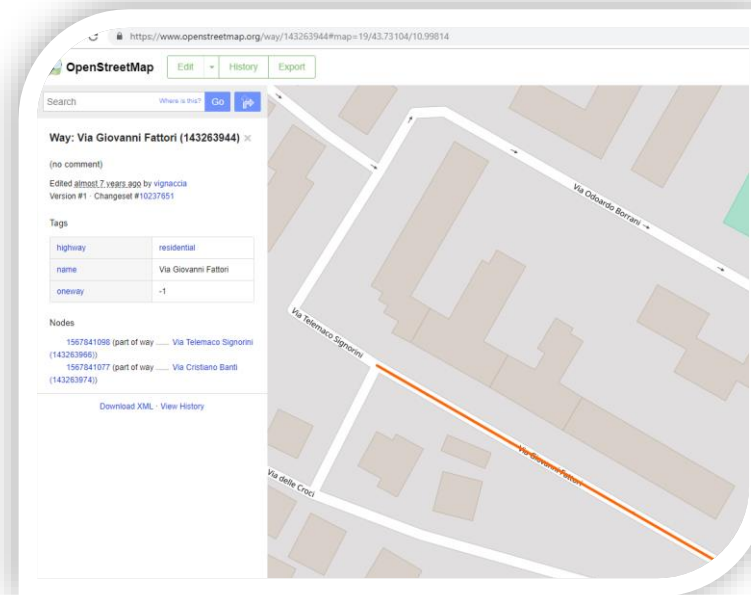
## Km4City KB

- `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](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
<a href="http://www.w3.org/1999/02/22-rdf-syntax-ns#type">http://www.w3.org/1999/02/22-rdf-syntax-ns#type</a>	<a href="http://www.disit.org/km4city/schema#Road">http://www.disit.org/km4city/schema#Road</a>
<a href="http://purl.org/dc/terms/identifier">http://purl.org/dc/terms/identifier</a>	"OS00143263944SR"
<a href="http://www.disit.org/km4city/schema#containsElement">http://www.disit.org/km4city/schema#containsElement</a>	<a href="http://www.disit.org/km4city/resource/OS00143263944RE/0">http://www.disit.org/km4city/resource/OS00143263944RE/0</a>
<a href="http://www.disit.org/km4city/schema#extendName">http://www.disit.org/km4city/schema#extendName</a>	"Via Giovanni Fattori"
<a href="http://www.disit.org/km4city/schema#inMunicipalityOf">http://www.disit.org/km4city/schema#inMunicipalityOf</a>	<a href="http://www.disit.org/km4city/resource/OS00000042586CO">http://www.disit.org/km4city/resource/OS00000042586CO</a>
<a href="http://www.disit.org/km4city/schema#roadName">http://www.disit.org/km4city/schema#roadName</a>	"Giovanni Fattori"
<a href="http://www.disit.org/km4city/schema#roadType">http://www.disit.org/km4city/schema#roadType</a>	"via"

## Open Street Map

- <https://www.openstreetmap.org/way/143263944>



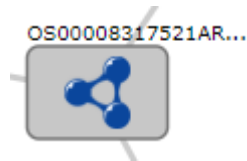
# Km4City Ontology: AdministrativeRoad



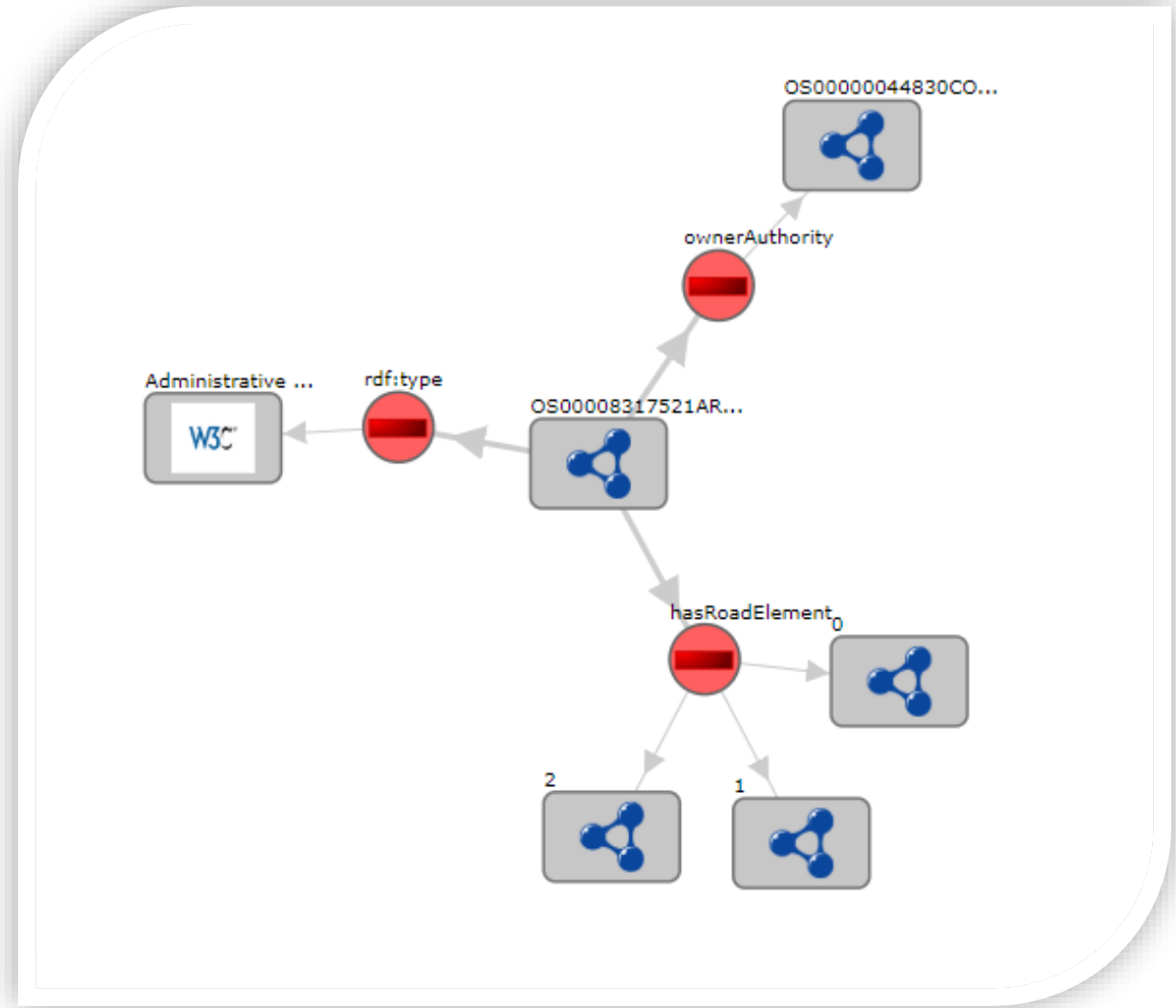
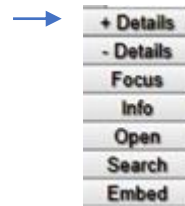
# DISIT LOG: Values of Object Properties of a Resource

<https://log.disit.org/service/index.php?uri=http://www.disit.org/km4city/resource/OS0000017556LR/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
<a href="http://www.w3.org/1999/02/22-rdf-syntax-ns#type">http://www.w3.org/1999/02/22-rdf-syntax-ns#type</a>	<a href="http://www.disit.org/km4city/schema#AdministrativeRoad">http://www.disit.org/km4city/schema#AdministrativeRoad</a>
<a href="http://www.disit.org/km4city/schema#ownerAuthority">http://www.disit.org/km4city/schema#ownerAuthority</a>	<a href="http://www.disit.org/km4city/resource/OS00000044830CO">http://www.disit.org/km4city/resource/OS00000044830CO</a>
<a href="http://www.disit.org/km4city/schema#hasRoadElement">http://www.disit.org/km4city/schema#hasRoadElement</a>	<a href="http://www.disit.org/km4city/resource/OS00008317521RE/0">http://www.disit.org/km4city/resource/OS00008317521RE/0</a>
<a href="http://www.disit.org/km4city/schema#hasRoadElement">http://www.disit.org/km4city/schema#hasRoadElement</a>	<a href="http://www.disit.org/km4city/resource/OS00008317521RE/1">http://www.disit.org/km4city/resource/OS00008317521RE/1</a>
<a href="http://www.disit.org/km4city/schema#hasRoadElement">http://www.disit.org/km4city/schema#hasRoadElement</a>	<a href="http://www.disit.org/km4city/resource/OS00008317521RE/2">http://www.disit.org/km4city/resource/OS00008317521RE/2</a>

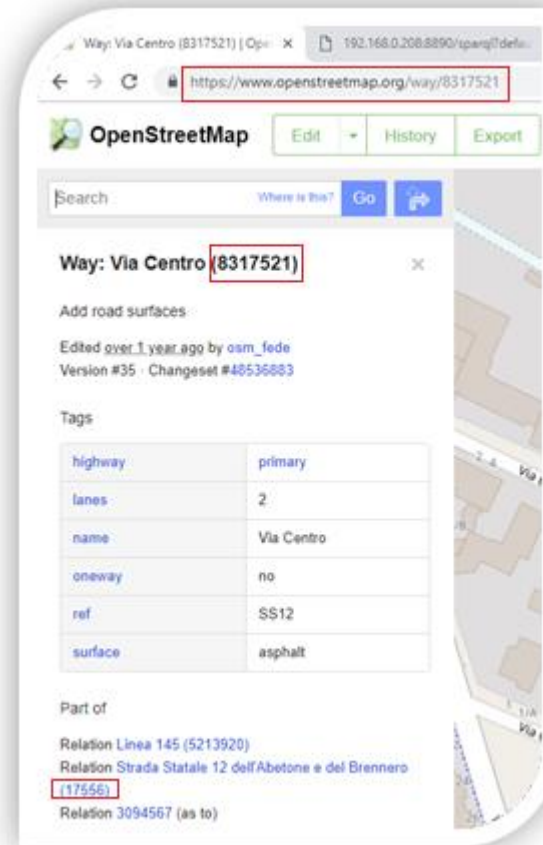
# AdministrativeRoad Resource: KM4C KB vs OSM

## Km4City KB

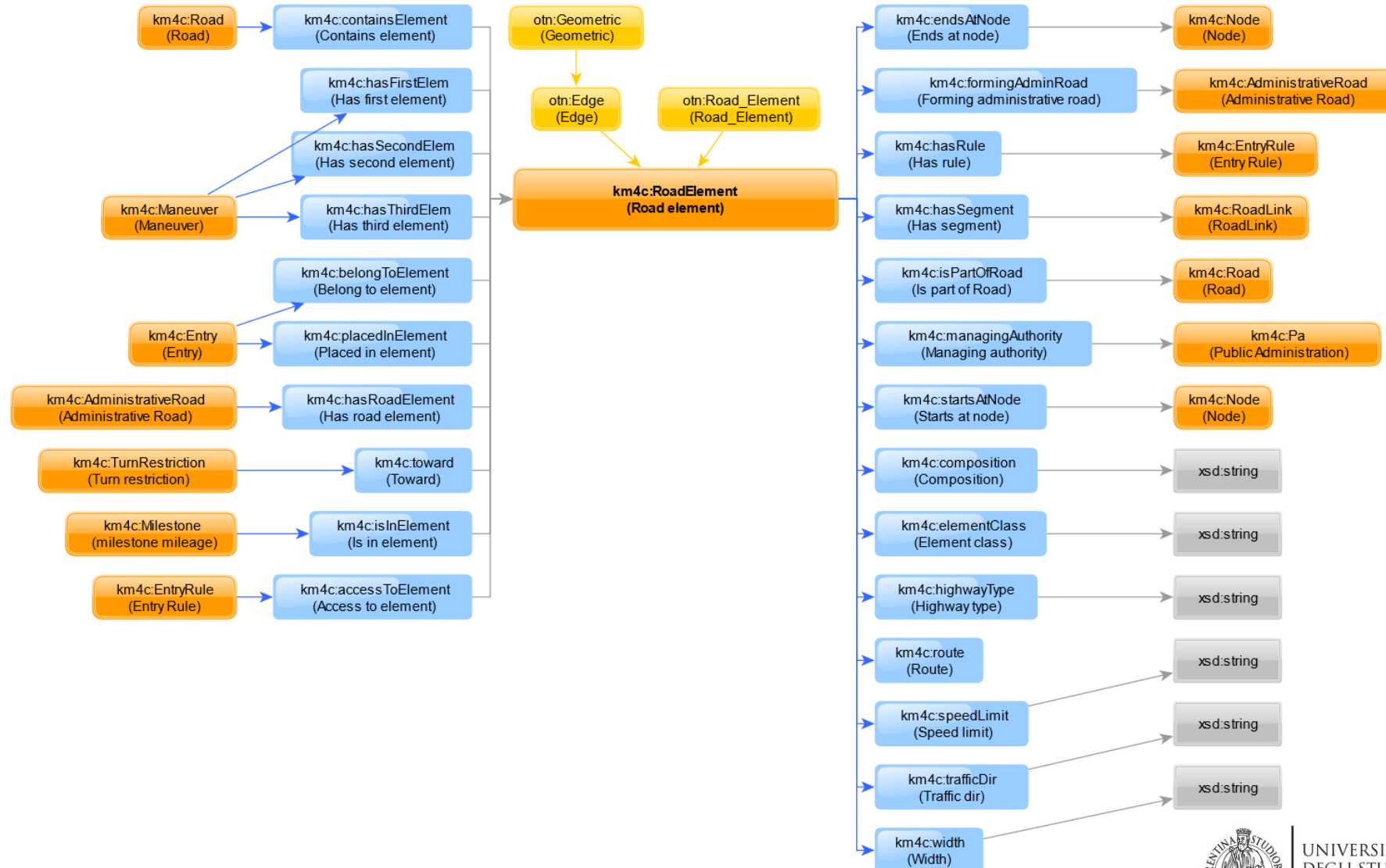
- ```
select * {
  <http://www.disit.org/km4city/resource/OS00000017556LR/OS000008317521AR> ?p ?v }
```
- ```
http://192.168.0.208:8890/sparql?default-graph-uri=&query=select+*+%7B+%3Chttp%3A%2F%2Fwww.disit.org%2Fkm4city%2Fresource%2FOS00000017556LR%2FOS000008317521AR%3E+%3Fp+%3Fv+%7D&format=text%2Fhtml&timeout=0&debug=on
```

p	v
<a href="http://www.w3.org/1999/02/22-rdf-syntax-ns#type">http://www.w3.org/1999/02/22-rdf-syntax-ns#type</a>	<a href="http://www.disit.org/km4city/schema#AdministrativeRoad">http://www.disit.org/km4city/schema#AdministrativeRoad</a>
<a href="http://purl.org/dc/terms/alternative">http://purl.org/dc/terms/alternative</a>	"Strada Statale 12 dell'Abetone e del Brennero"
<a href="http://purl.org/dc/terms/identifier">http://purl.org/dc/terms/identifier</a>	"OS00000017556LR/OS000008317521AR"
<a href="http://www.disit.org/km4city/schema#adRoadNameGeneric">http://www.disit.org/km4city/schema#adRoadNameGeneric</a>	"via"
<a href="http://www.disit.org/km4city/schema#adRoadNameSpecific">http://www.disit.org/km4city/schema#adRoadNameSpecific</a>	"Centro"
<a href="http://www.disit.org/km4city/schema#adRoadName">http://www.disit.org/km4city/schema#adRoadName</a>	"Via Centro"
<a href="http://www.disit.org/km4city/schema#adminClass">http://www.disit.org/km4city/schema#adminClass</a>	"strada statale"
<a href="http://www.disit.org/km4city/schema#hasRoadElement">http://www.disit.org/km4city/schema#hasRoadElement</a>	<a href="http://www.disit.org/km4city/resource/OS00008317521RE/0">http://www.disit.org/km4city/resource/OS00008317521RE/0</a>
<a href="http://www.disit.org/km4city/schema#hasRoadElement">http://www.disit.org/km4city/schema#hasRoadElement</a>	<a href="http://www.disit.org/km4city/resource/OS00008317521RE/1">http://www.disit.org/km4city/resource/OS00008317521RE/1</a>
<a href="http://www.disit.org/km4city/schema#hasRoadElement">http://www.disit.org/km4city/schema#hasRoadElement</a>	<a href="http://www.disit.org/km4city/resource/OS00008317521RE/2">http://www.disit.org/km4city/resource/OS00008317521RE/2</a>
<a href="http://www.disit.org/km4city/schema#ownerAuthority">http://www.disit.org/km4city/schema#ownerAuthority</a>	<a href="http://www.disit.org/km4city/resource/OS000004483OCO">http://www.disit.org/km4city/resource/OS000004483OCO</a>

## Open Street Map



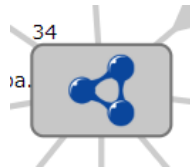
# Km4City Ontology: RoadElement



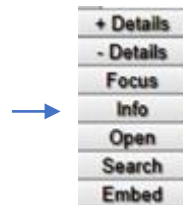
# DISIT LOG: Data Properties & Values of a Resource

<https://log.disit.org/service/index.php?uri=http://www.disit.org/km4city/resource/OS0023122303RE/34&sparql=http://192.168.0.208:8890/sparql>

1. Right-click on



2. And hit **Info**



Info: Close

**dct: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

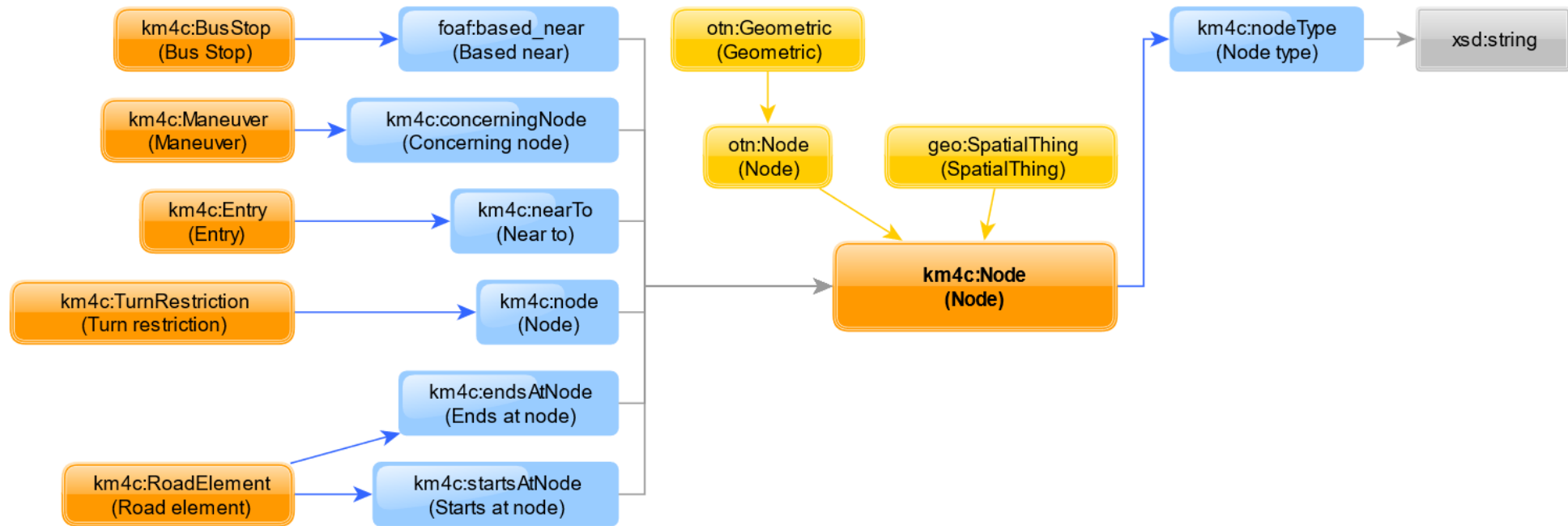


# SPARQL Query: Values of Data Properties (of a given Resource)

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

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

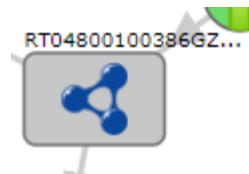
# Km4City Ontology: Node



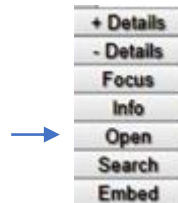
# DISIT LOG: Exploit Linked Data

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

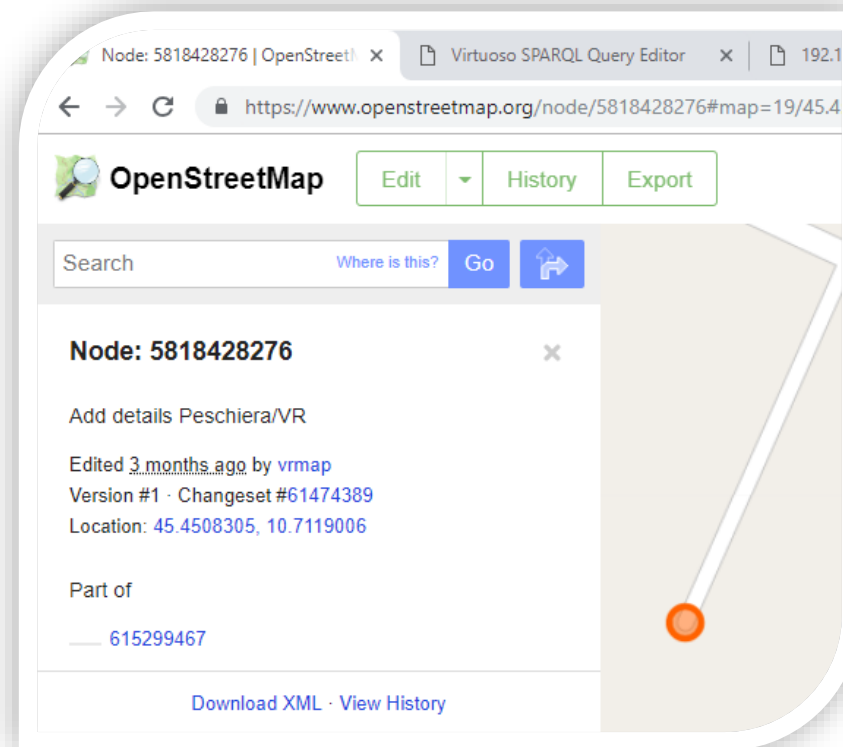
# Node *Resource*: Km4City KB vs OSM

## Km4City KB

- ```
select * {  
  <http://www.disit.org/km4city/resource/OS05818428276NO> ?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**

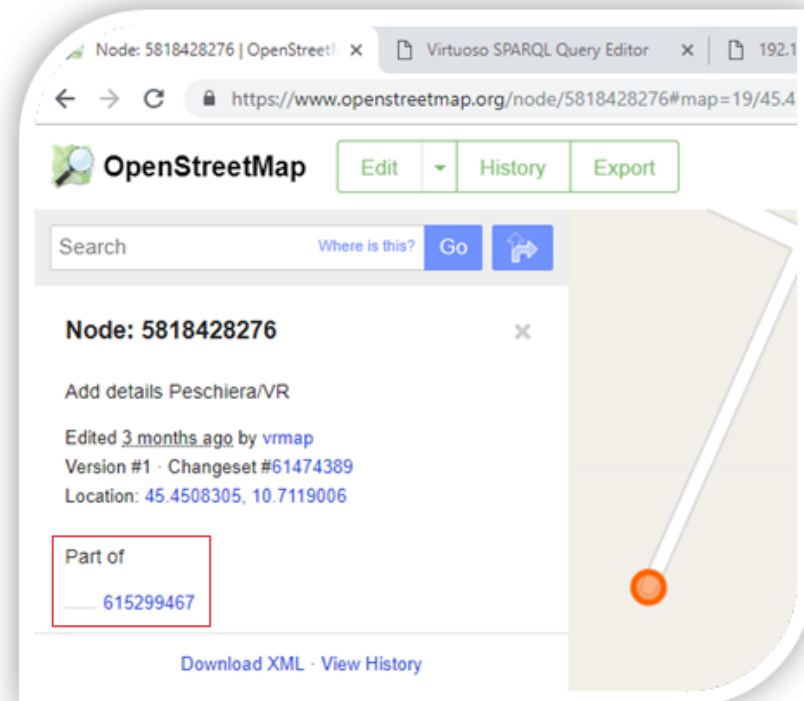
<http://www.disit.org/km4city/resource/OS00615299467RE/0>

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

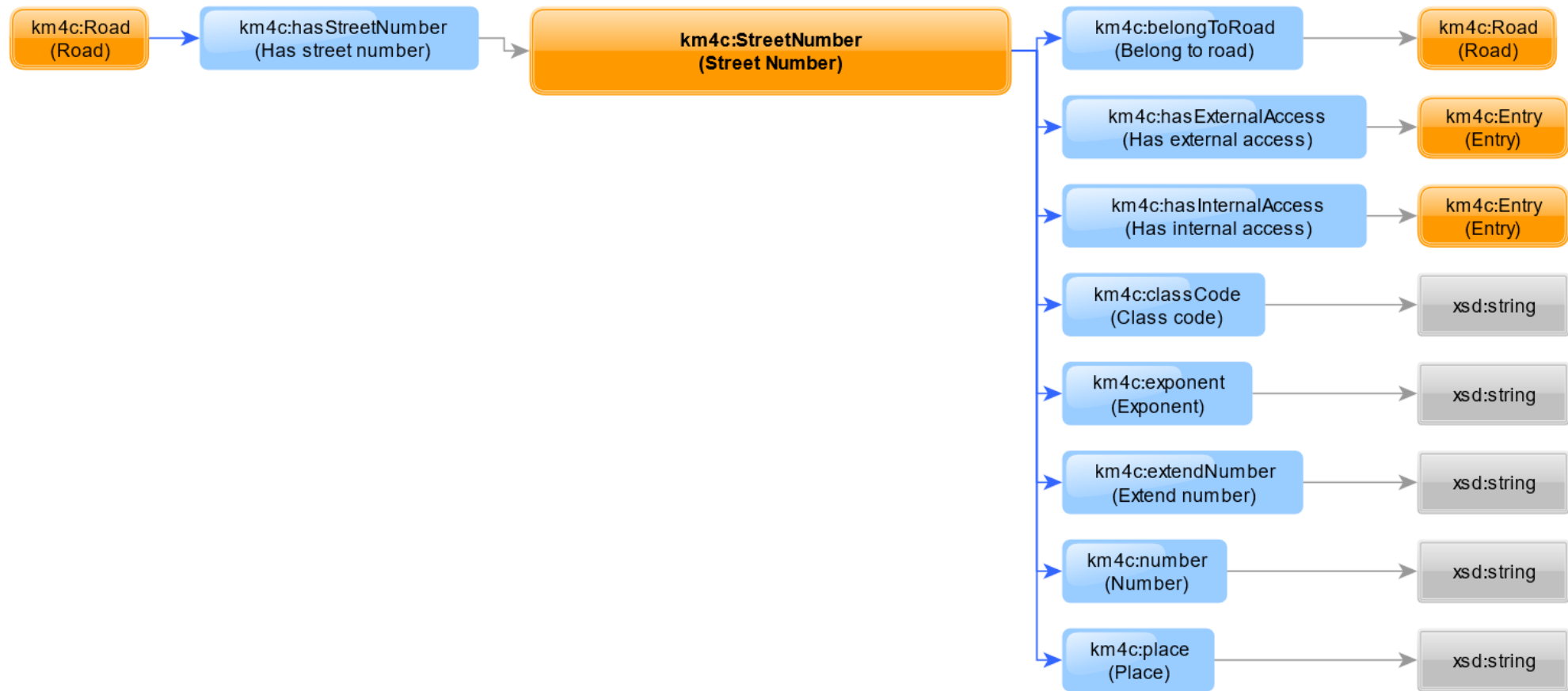
r

<http://www.disit.org/km4city/resource/OS00615299467SR>

Open Street Map



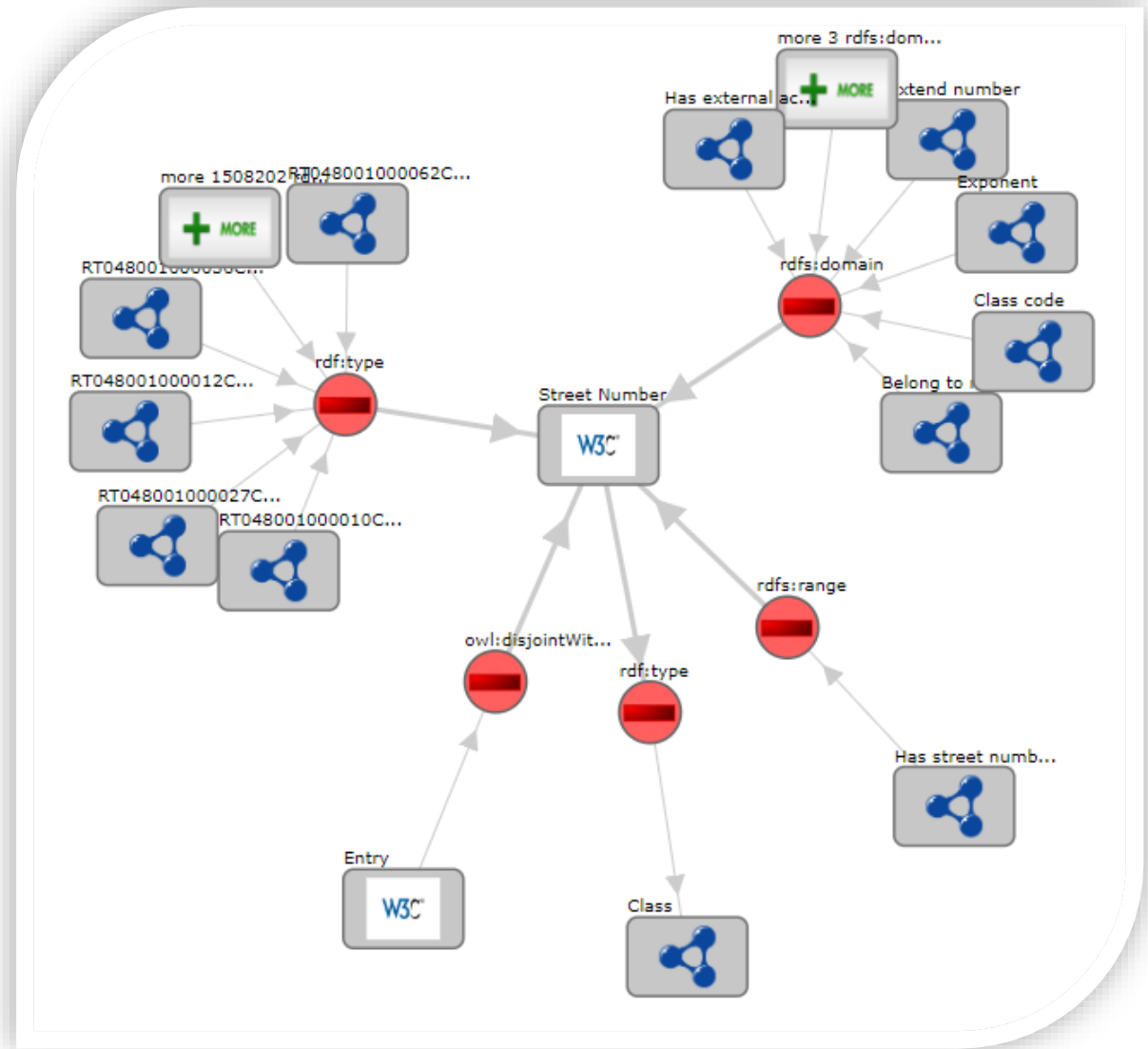
Km4City Ontology: StreetNumber



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 |

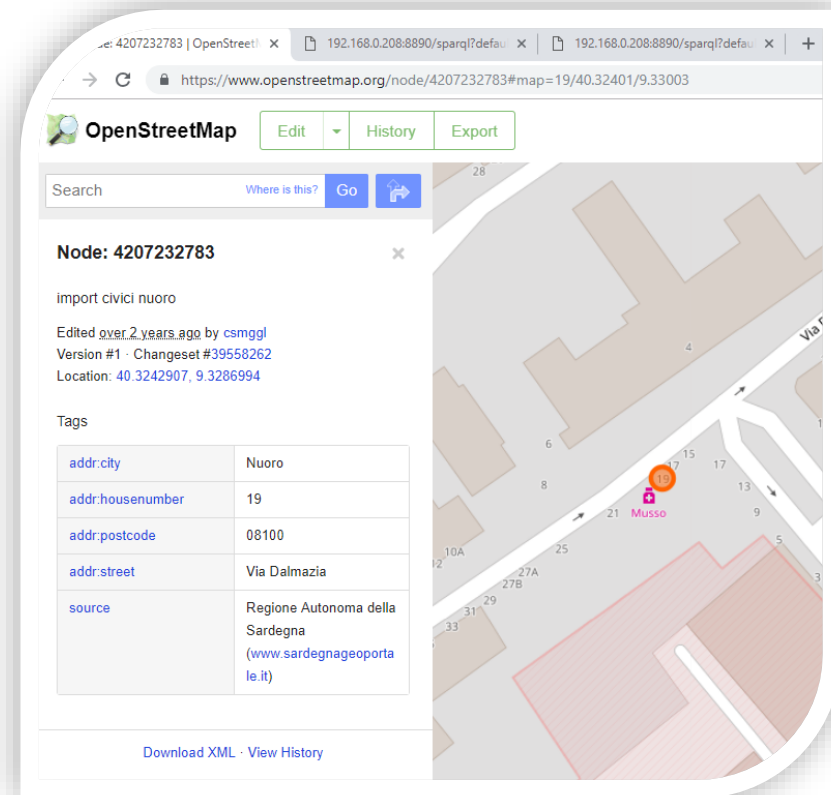
Street Number *Resource*: Km4City KB vs OSM

Km4City KB

- ```
select distinct ?rn ?n {
 <http://www.disit.org/km4city/resource/OS04207232783NN>
 km4c:extendNumber ?n ;
 km4c:belongToRoad ?r .
 ?r km4c:extendName ?rn
}
```

<b>rn</b>	<b>n</b>
"Via Dalmazia"	"19"

## Open Street Map



OpenStreetMap

Search  Where is this?

**Node: 4207232783**

import civici nuoro

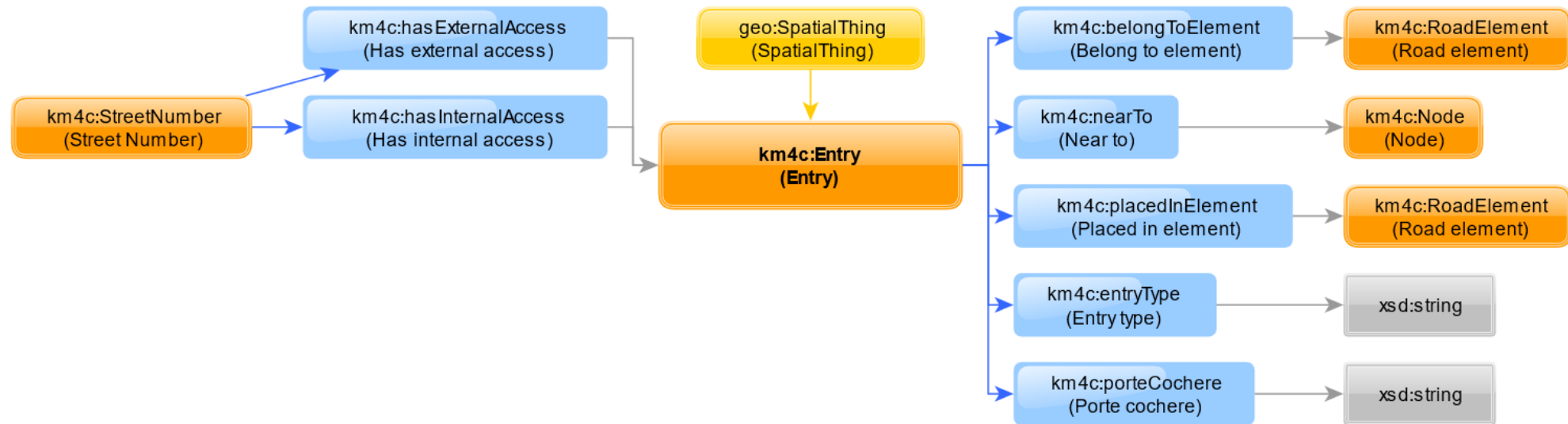
Edited [over 2 years ago](#) by [csmggl](#)  
Version #1 · Changeset #39558262  
Location: [40.3242907, 9.3286994](#)

Tags

addr:city	Nuoro
addr:houseNumber	19
addr:postcode	08100
addr:street	Via Dalmazia
source	Regione Autonoma della Sardegna ( <a href="http://www.sardegnaeoporta.le.it">www.sardegnaeoporta.le.it</a> )

[Download XML](#) · [View History](#)

# 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*.

Entry Close

**Identifier:**  
http://www.disit.org/km4city/schema#Entry

**Image:**



**Info:**

**rdfs:label**

Entry

**rdfs:comment**

Classe le cui istanze sono i possibili ingressi ai numeri civici

**Sparql Query:**

ENDPOINT:  
http://192.168.0.206:8890/sparql

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

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

# Entry *Resource*: Km4City KB vs OSM

## Km4City KB

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



| 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 > |

Open Street Map

Node: 4207232783

import civici nuoro

Edited over 2 years ago by csmggl

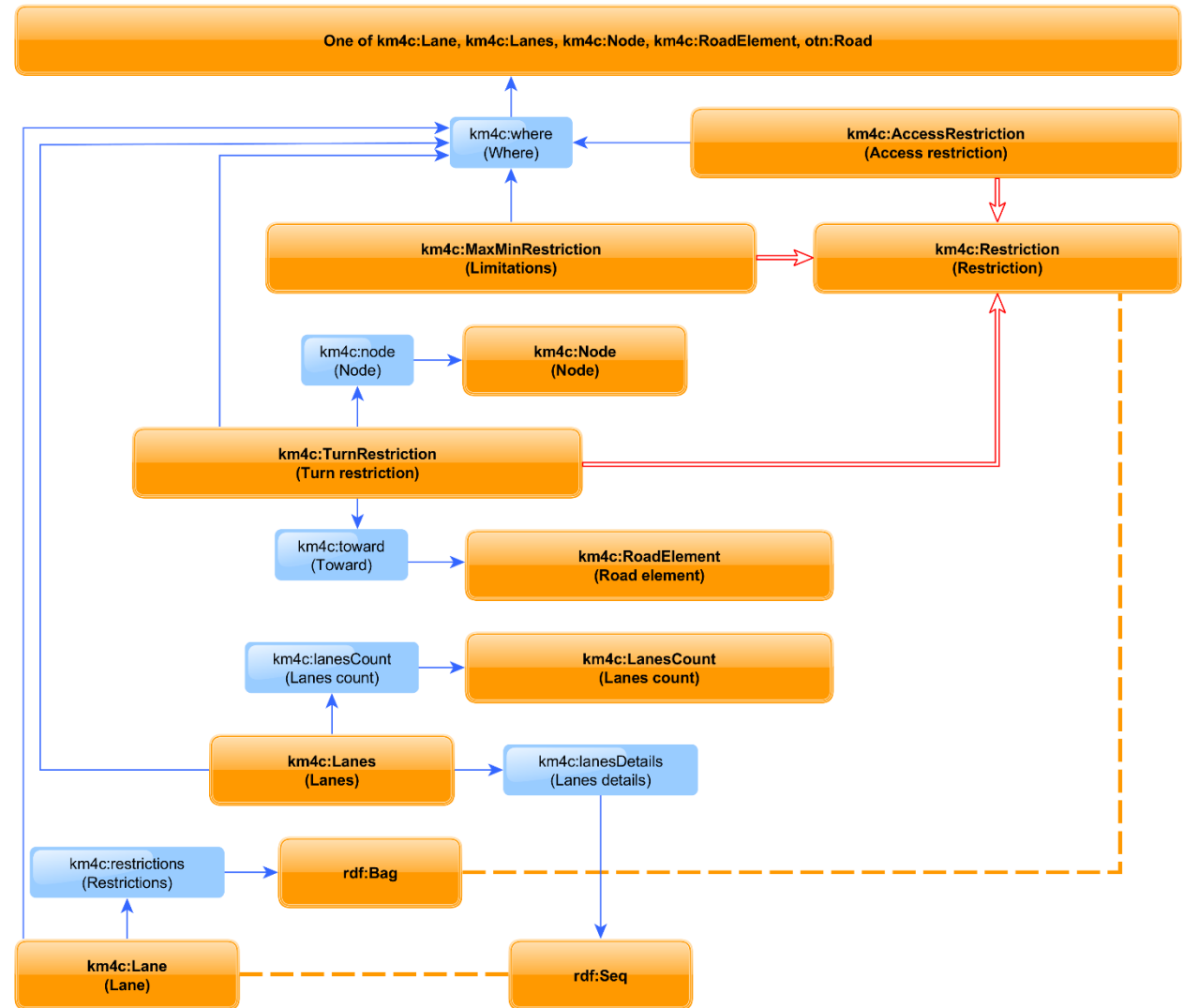
Version #1 · Changeset #39558262

Location: 40.3242907, 9.3286994

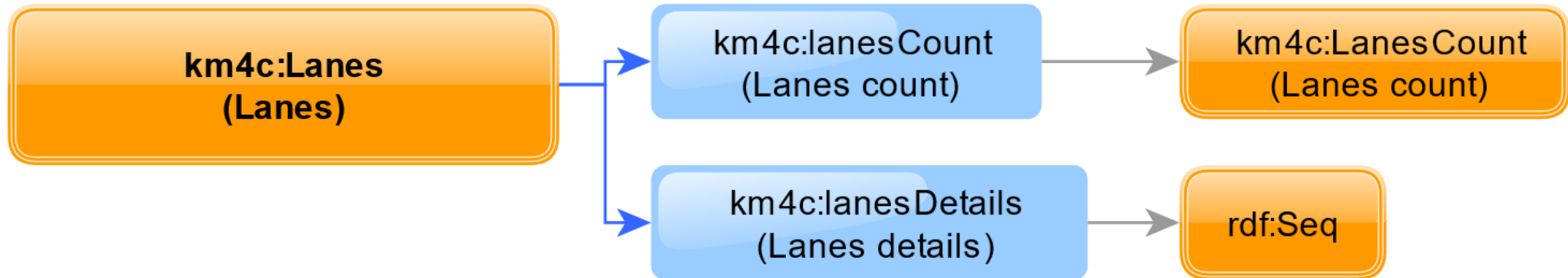


Km4City Ontology: Street Graph (v1.6.5)

- 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

The screenshot displays a software interface with a list of properties on the left and two panels on the right. The list of properties includes: observes, ofFeature, onRoute, ownerAuthority, phenomenonTime, placedInElement, placedOnRoad, qualityOfObservation, refersToMunicipality, refersToRide, refersToRoadElement, relatedToSensor, restrictions, satisfies, scheduledOnLine, startAtJunction, startingJunction, startsAtNode, startsAtStop, toward, type, updateTime, usedProcedure, value_type, wasOriginatedBy, wasteType, and where. The 'where' property is highlighted. The 'Characteristics: where' panel contains a list of checkboxes: Functional, Inverse functional, Transitive, Symmetric, Asymmetric, Reflexive, and Irreflexive. The 'Description: where' panel shows a hierarchy of relationships: Equivalent To, SubProperty Of, Inverse Of, Domains (intersection), and Ranges (intersection). The Domains (intersection) section lists: AccessRestriction or Lane or Lanes or MaxMinRestriction or TurnRestriction. The Ranges (intersection) section lists: Lane or Lanes or Node or RoadElement or Road. A Disjoint With button is also visible at the bottom.

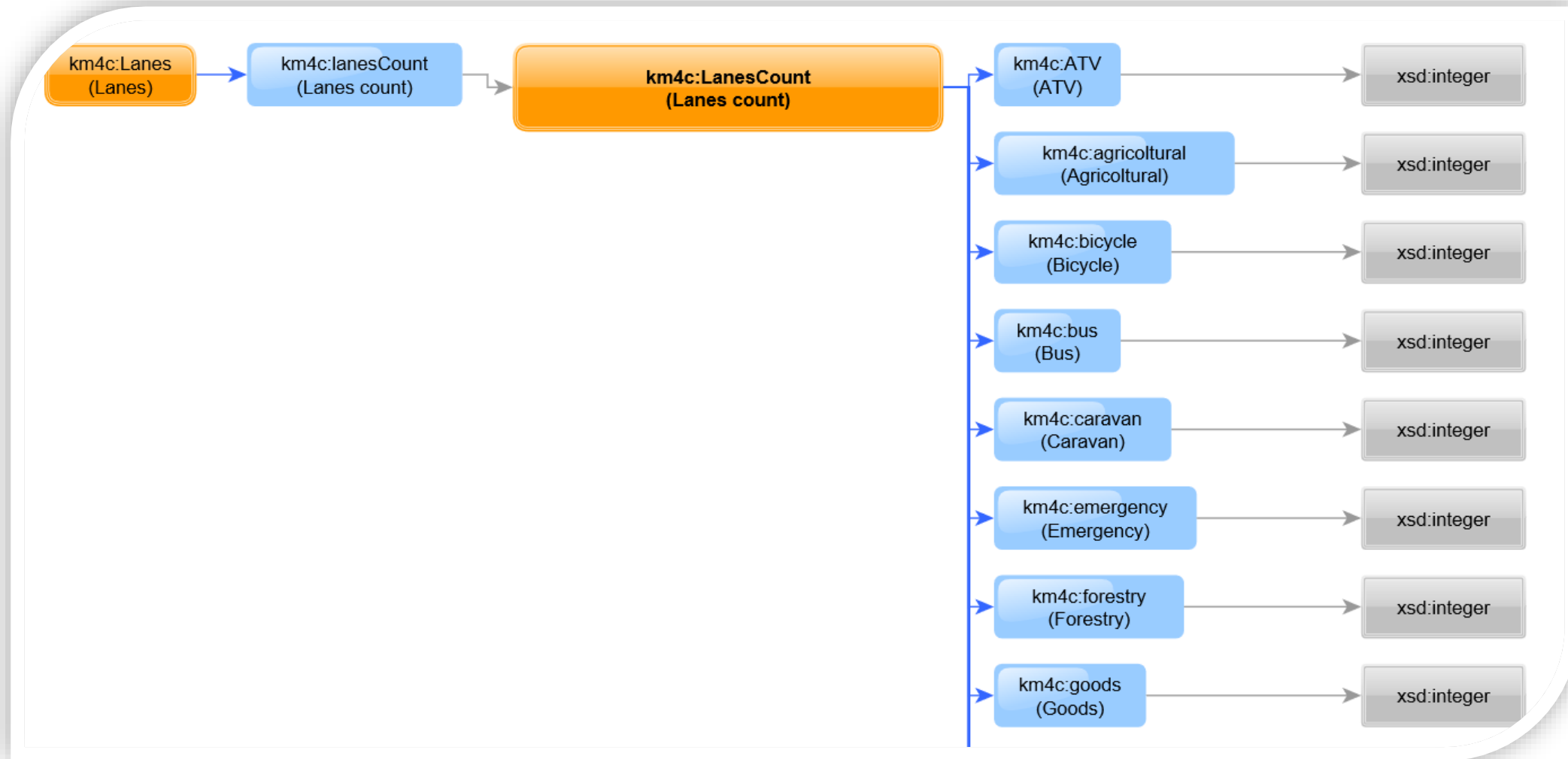
SPARQL Query: Lanes

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

| ls | lsp | lsv |
|---|---|---|
| http://www.disit.org/km4city/resource/OS00000031192LR/lanes/alldirections | http://www.disit.org/km4city/schema#lanesCount | http://www.disit.org/km4city/resource/OS00000031192LR/lanes/alldirections/count |
| http://www.disit.org/km4city/resource/OS00000031192LR/lanes/alldirections | http://www.disit.org/km4city/schema#where | http://www.disit.org/km4city/resource/OS00000031192LR |
| http://www.disit.org/km4city/resource/OS00000031192LR/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/OS00002132537RE/0/lanes/alldirections | http://www.disit.org/km4city/schema#lanesCount | http://www.disit.org/km4city/resource/OS00002132537RE/0/lanes/alldirections/count |
| http://www.disit.org/km4city/resource/OS00002132537RE/0/lanes/alldirections | http://www.disit.org/km4city/schema#where | http://www.disit.org/km4city/resource/OS00002132537RE/0 |
| http://www.disit.org/km4city/resource/OS00002132537RE/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/OS00002132537RE/1/lanes/alldirections | http://www.disit.org/km4city/schema#lanesCount | http://www.disit.org/km4city/resource/OS00002132537RE/1/lanes/alldirections/count |
| http://www.disit.org/km4city/resource/OS00002132537RE/1/lanes/alldirections | http://www.disit.org/km4city/schema#where | http://www.disit.org/km4city/resource/OS00002132537RE/1 |
| http://www.disit.org/km4city/resource/OS00002132537RE/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/OS00002132537RE/2/lanes/alldirections | http://www.disit.org/km4city/schema#lanesCount | http://www.disit.org/km4city/resource/OS00002132537RE/2/lanes/alldirections/count |
| http://www.disit.org/km4city/resource/OS00002132537RE/2/lanes/alldirections | http://www.disit.org/km4city/schema#where | http://www.disit.org/km4city/resource/OS00002132537RE/2 |
| http://www.disit.org/km4city/resource/OS00002132537RE/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/OS00002132546RE/0/lanes/alldirections | http://www.disit.org/km4city/schema#lanesCount | http://www.disit.org/km4city/resource/OS00002132546RE/0/lanes/alldirections/count |
| http://www.disit.org/km4city/resource/OS00002132546RE/0/lanes/alldirections | http://www.disit.org/km4city/schema#where | http://www.disit.org/km4city/resource/OS00002132546RE/0 |
| http://www.disit.org/km4city/resource/OS00002132546RE/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/OS00002132546RE/1/lanes/alldirections | http://www.disit.org/km4city/schema#lanesCount | http://www.disit.org/km4city/resource/OS00002132546RE/1/lanes/alldirections/count |
| http://www.disit.org/km4city/resource/OS00002132546RE/1/lanes/alldirections | http://www.disit.org/km4city/schema#where | http://www.disit.org/km4city/resource/OS00002132546RE/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#undesigned | 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#undesigned | "1" |
| http://www.disit.org/km4city/schema#bus | "1" |



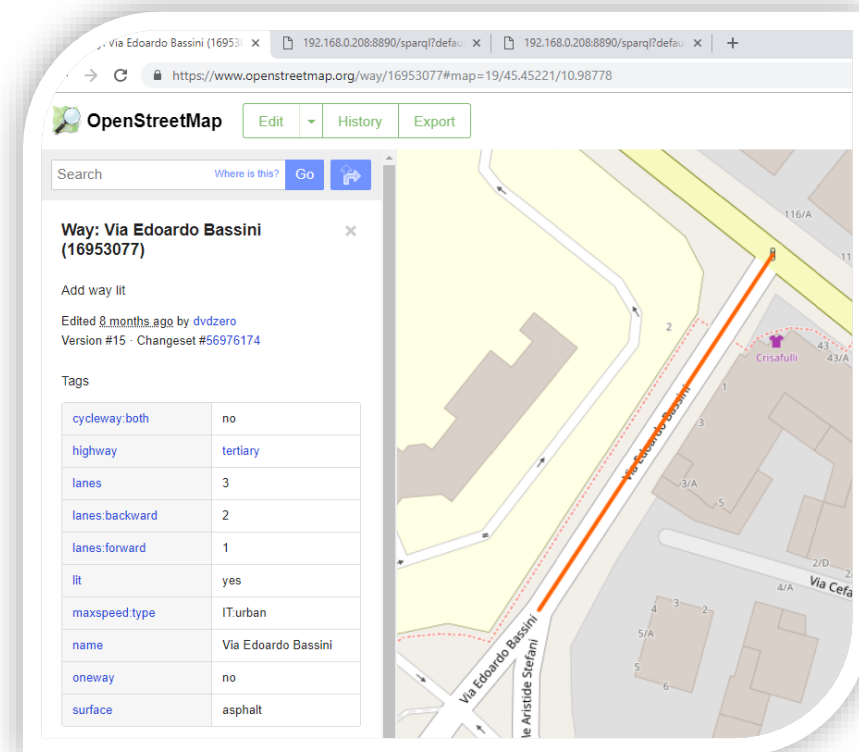
Lanes Count: Km4City KB vs OSM

Km4City KB

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

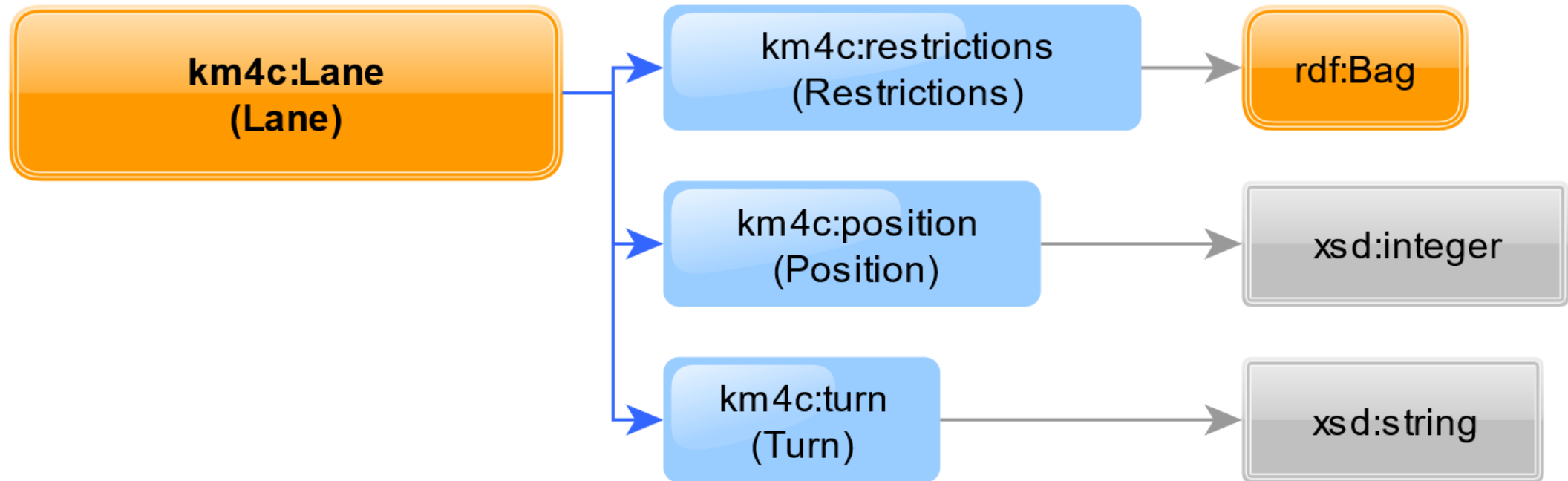
lanescount	v
<a href="http://www.disit.org/km4city/resource/OS00016953077SR/lanes/alldirections/count">http://www.disit.org/km4city/resource/OS00016953077SR/lanes/alldirections/count</a>	3
<a href="http://www.disit.org/km4city/resource/OS00016953077SR/lanes/backward/count">http://www.disit.org/km4city/resource/OS00016953077SR/lanes/backward/count</a>	2
<a href="http://www.disit.org/km4city/resource/OS00016953077SR/lanes/forward/count">http://www.disit.org/km4city/resource/OS00016953077SR/lanes/forward/count</a>	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
<a href="http://www.w3.org/1999/02/22-rdf-syntax-ns#type">http://www.w3.org/1999/02/22-rdf-syntax-ns#type</a>	<a href="http://www.disit.org/km4city/schema#Lane">http://www.disit.org/km4city/schema#Lane</a>
<a href="http://www.disit.org/km4city/schema#where">http://www.disit.org/km4city/schema#where</a>	<a href="http://www.disit.org/km4city/resource/OS00036055473RE/0/lanes/backward">http://www.disit.org/km4city/resource/OS00036055473RE/0/lanes/backward</a>
<a href="http://www.disit.org/km4city/schema#position">http://www.disit.org/km4city/schema#position</a>	"2"
<a href="http://www.disit.org/km4city/schema#turn">http://www.disit.org/km4city/schema#turn</a>	"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
<a href="http://www.disit.org/km4city/resource/OS00036055473RE/0/lanes/alldirections">http://www.disit.org/km4city/resource/OS00036055473RE/0/lanes/alldirections</a>
<a href="http://www.disit.org/km4city/resource/OS00036055473RE/0/lanes/backward">http://www.disit.org/km4city/resource/OS00036055473RE/0/lanes/backward</a>
<a href="http://www.disit.org/km4city/resource/OS00036055473RE/0/lanes/forward">http://www.disit.org/km4city/resource/OS00036055473RE/0/lanes/forward</a>

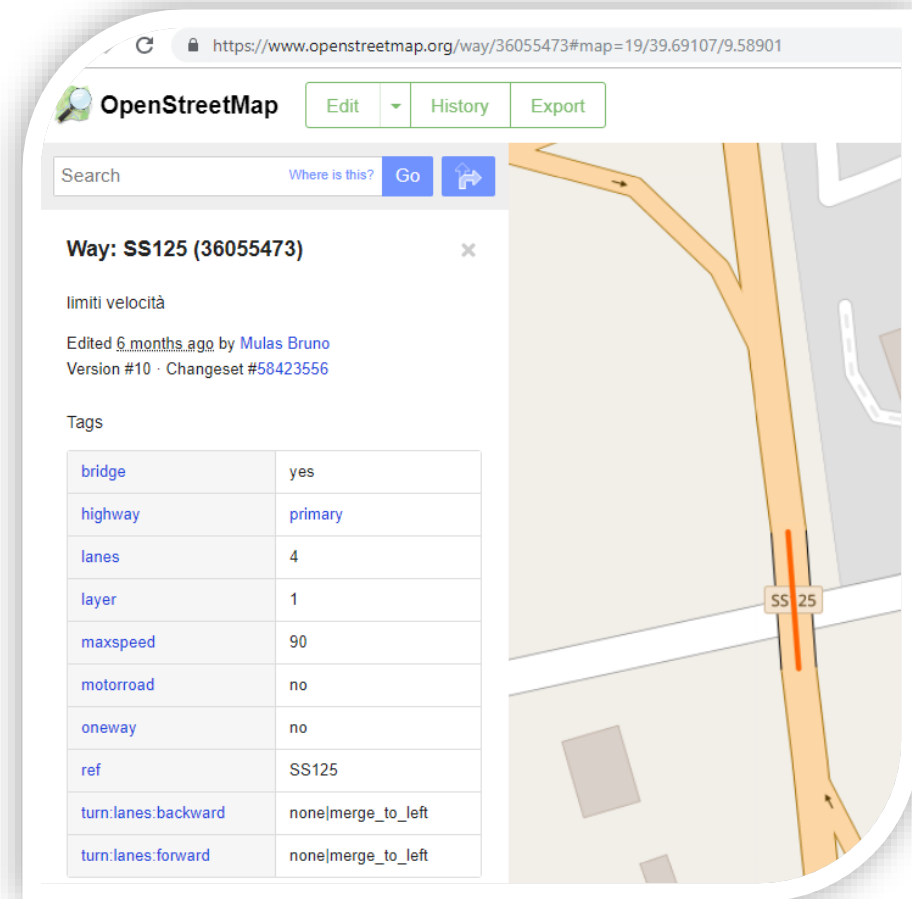
- `select ?p ?v {  
 <http://www.disit.org/km4city/resource/OS00036055473RE/0/lanes/backward>  
 km4c:lanesDetails ?list . ?list ?p ?v }`

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

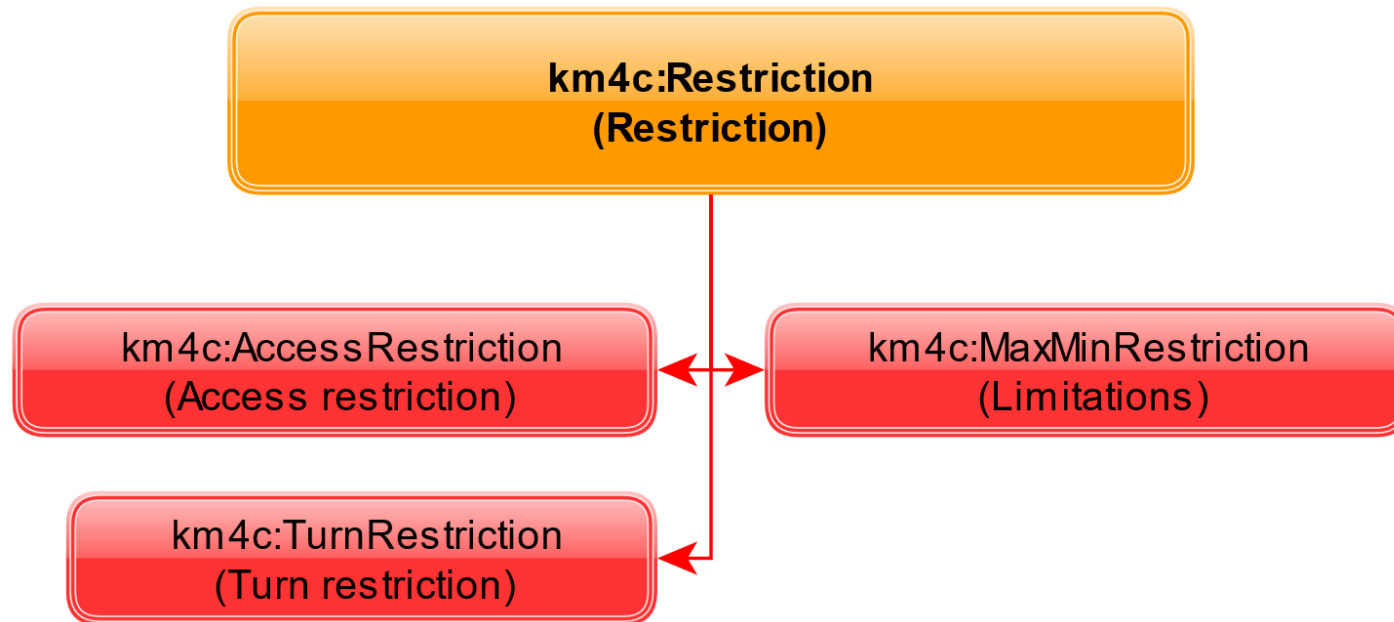
- `select * {  
 <http://www.disit.org/km4city/resource/OS00036055473RE/0/lanes/backward/2> ?p ?v  
 }`

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

## Open Street Map



# Km4City Ontology: Restriction



# SPARQL Query: Discover restrictions on a road

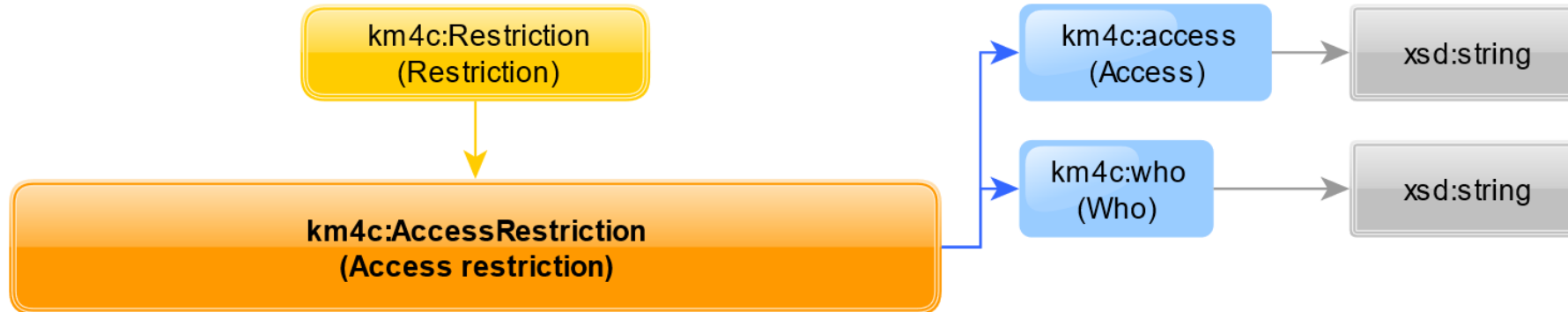
```
select * {
 ?r a km4c:Restriction;
 km4c:where <http://www.disit.org/km4city/resource/OS00023116033SR>
}
```

**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
<a href="http://www.w3.org/1999/02/22-rdf-syntax-ns#type">http://www.w3.org/1999/02/22-rdf-syntax-ns#type</a>	<a href="http://www.disit.org/km4city/schema#AccessRestriction">http://www.disit.org/km4city/schema#AccessRestriction</a>
<a href="http://www.w3.org/1999/02/22-rdf-syntax-ns#type">http://www.w3.org/1999/02/22-rdf-syntax-ns#type</a>	<a href="http://www.disit.org/km4city/schema#Restriction">http://www.disit.org/km4city/schema#Restriction</a>
<a href="http://www.disit.org/km4city/schema#access">http://www.disit.org/km4city/schema#access</a>	"no"
<a href="http://www.disit.org/km4city/schema#where">http://www.disit.org/km4city/schema#where</a>	<a href="http://www.disit.org/km4city/resource/OS00023116033SR">http://www.disit.org/km4city/resource/OS00023116033SR</a>
<a href="http://www.disit.org/km4city/schema#who">http://www.disit.org/km4city/schema#who</a>	"hgv"



# Open Street Map: Access Restriction

The screenshot shows the OpenStreetMap interface with a specific road, Via Caluri, highlighted in orange. The left sidebar displays the details for this road, including its ID (23116033), tags, and nodes. The map shows a residential area with buildings and green spaces. The orange line indicates a restriction on the road.

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**Way: Via Caluri (23116033)** [×](#)

(no comment)

Edited 7 months ago by [vrmap](#)  
Version #8 · Changeset #58225335

Tags

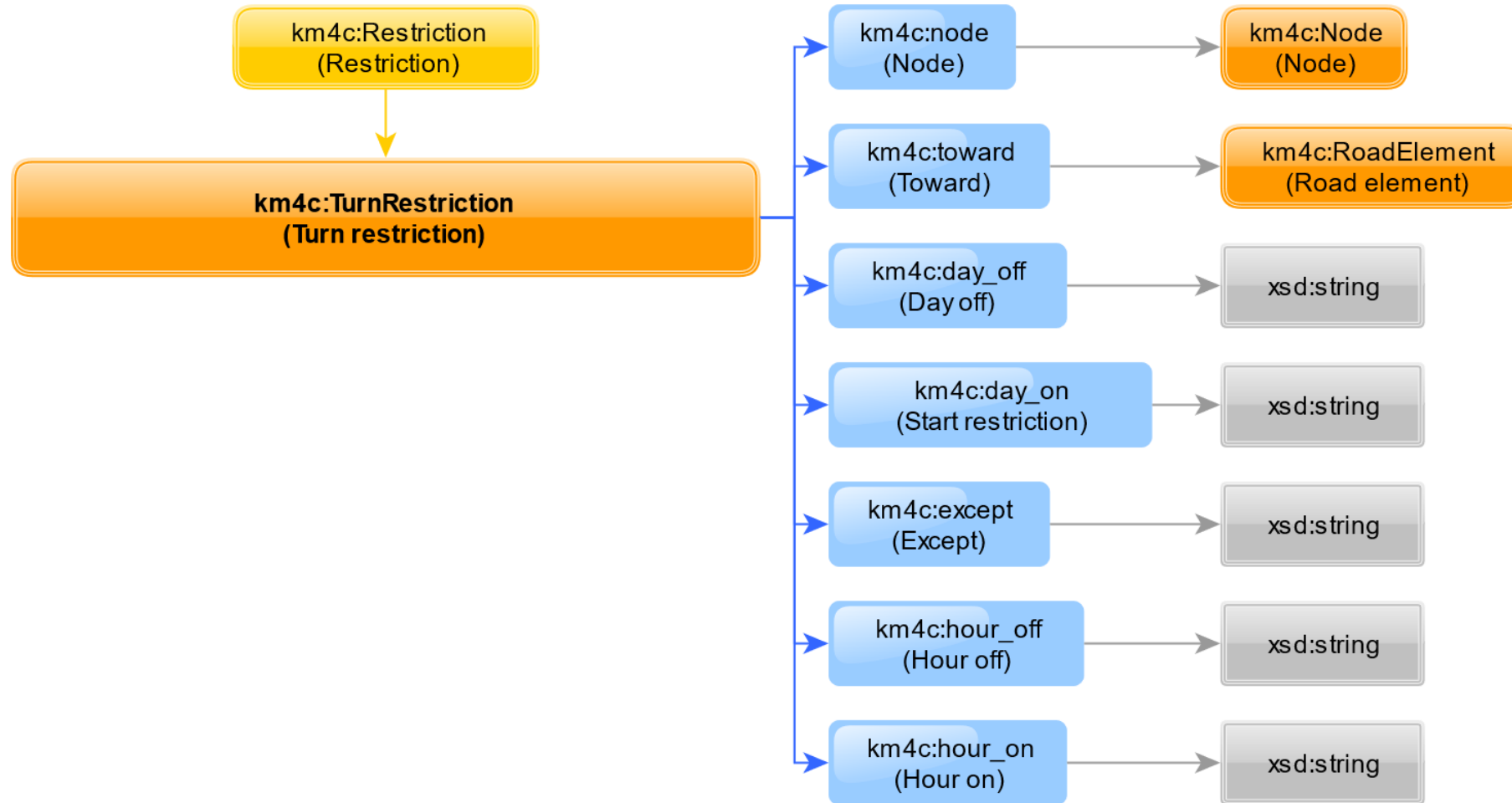
<a href="#">hgv</a>	no
<a href="#">highway</a>	<a href="#">residential</a>
<a href="#">name</a>	Via Caluri
<a href="#">surface</a>	asphalt

Nodes

- [2405361247](#) (part of way [-----](#) [232163131](#))
- [249561230](#)
- [249561266](#) (part of way [—](#) [Via Caluri \(23116036\)](#))
- [249561271](#) (part of way [—](#) [Via Caluri \(23116037\)](#))
- [249561232](#) (part of way [—](#) [Via Caluri \(26790820\)](#))

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



# Open Street Map: Turn Restriction

The screenshot shows the OpenStreetMap interface for a specific relation (8794382). The main map area displays a road network with a highlighted orange line representing a turn restriction. The restriction is applied to a segment of Strada Statale 434 Transpolesana, specifically at the intersection with Via Bongiovanni. The restriction is labeled as 'only\_straight\_on'.

**Relation: 8794382**

Added restrictions

Edited 28 days ago by [alesiom](#)  
Version #1 · Changeset #63359384

Tags

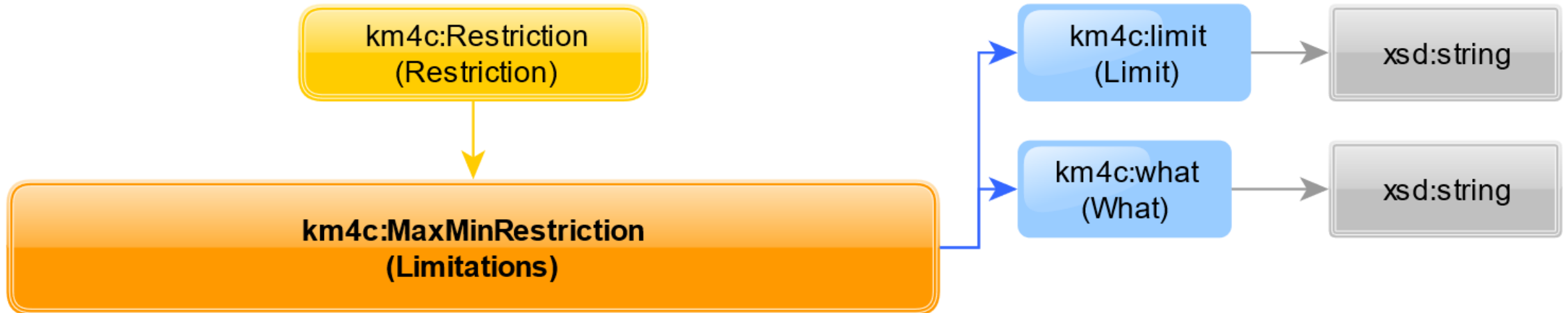
restriction	only_straight_on
type	restriction

Members

- Way 4059369 as from Node 21494562 as via
- Way Via Bongiovanni (4059328) as to

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# Km4City Ontology: MaxMinRestriction



# SPARQL Query: Size/Weight/... restriction (details)

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

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





# Open Street Map: Speed limit

The screenshot shows the OpenStreetMap interface with a search for 'Way: Corso Porta Nuova (4788596)'. The map displays a street network with various buildings, parks, and landmarks. The selected way is highlighted in orange, and its properties are shown in a table on the left.

Way: Corso Porta Nuova (4788596)

edit it

Edited 1 day ago by bosetic  
Version #29 · Changeset #64181570

Tags

highway	tertiary
lanes	3
maxspeed	50
maxspeed.type	sign
name	Corso Porta Nuova
oneway	yes
surface	asphalt

Part of

- Relation Linea 52 (8013045) (as forward)
- Relation Linea 51 (223558) (as forward)
- Relation Linea 141 (5214487)
- Relation Linea 145 (5213920)
- Relation Linea 144 (5176790)





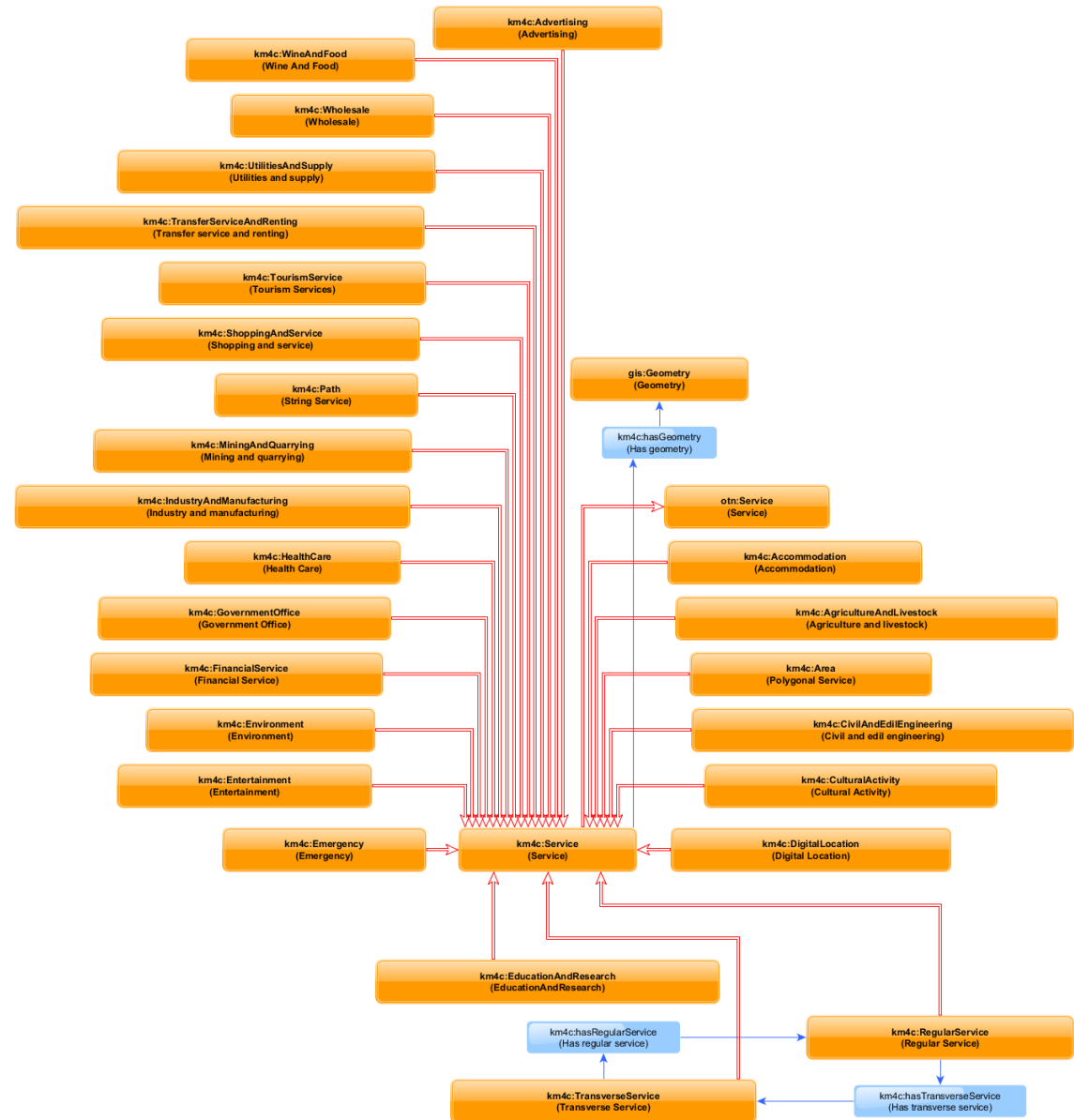
# Km4City Ontology: Points Of Interest

- Service

- RegularService

- WineAndFood
- Path
- HealthCare
- GovernmentOffice
- Entertainment
- Accommodation
- ...

- TransverseService



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# Km4City Ontology: Points of Interest

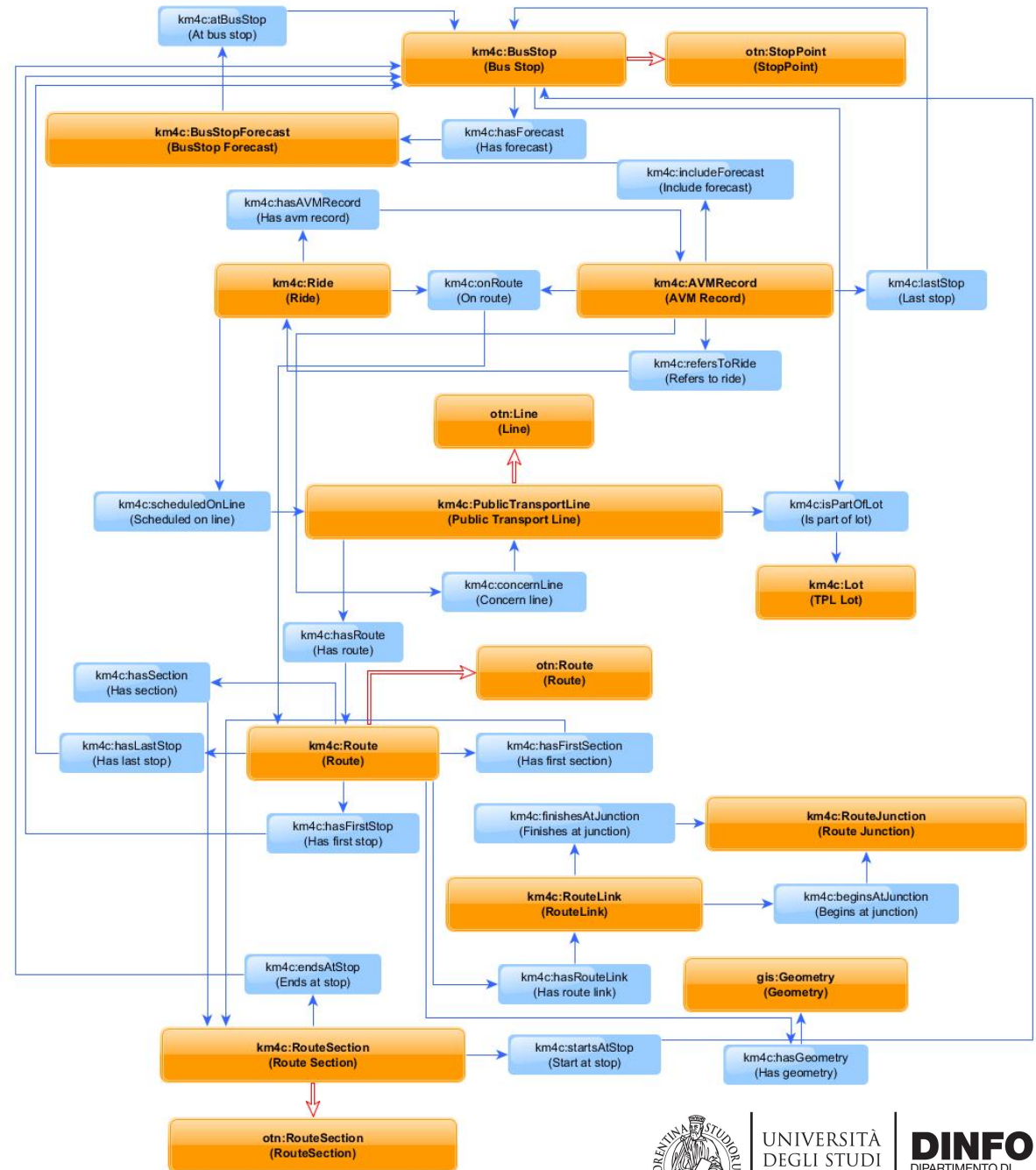
- Accomodation:
  - Holiday\_village
  - Hotel
  - Summer\_residence
  - Rest\_home
  - Hostel
  - Farm\_house
  - Beach\_resort
  - Agritourism
  - Vacation\_resort
  - Day\_care\_centre
  - Camping
  - Boarding\_house
  - Mountain\_shelter
  - Religiuos\_guest\_house
  - Bed\_and\_breakfast
  - Historic\_residence
  - 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

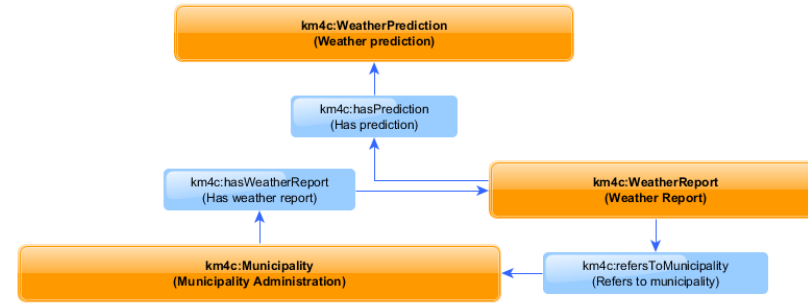
- Lot
- PublicTransportLine
- Route
- RouteSection
- RouteLink
- RouteJunction
- Ride
- BusStop
- AVMRecord
- BusStopForecast
- Geometry





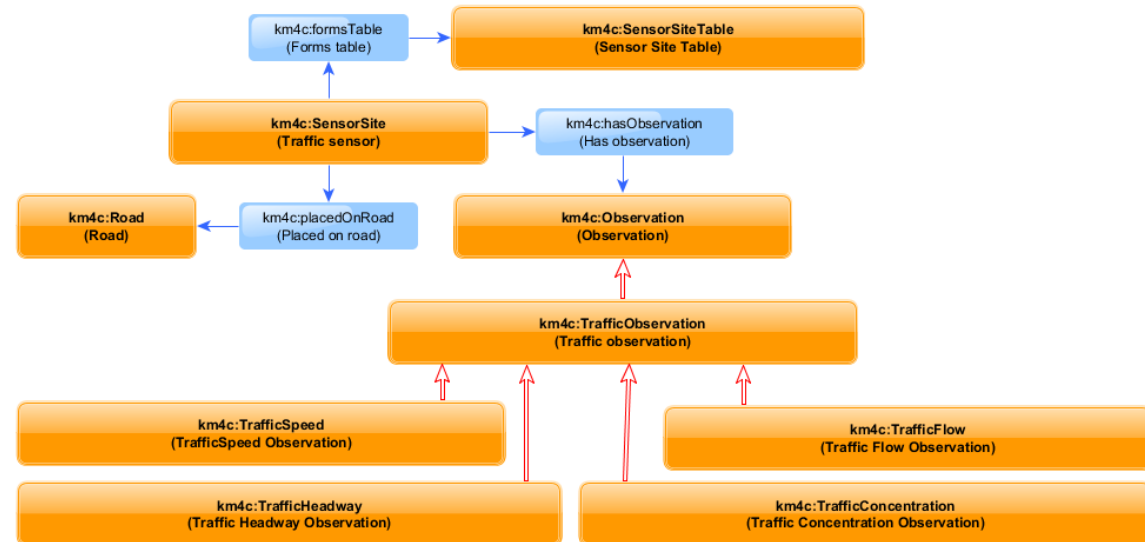
# Km4City Ontology: Weather Forecasts

- Municipality
- WeatherReport
- WeatherPrediction



# Km4City Ontology: Traffic Sensors

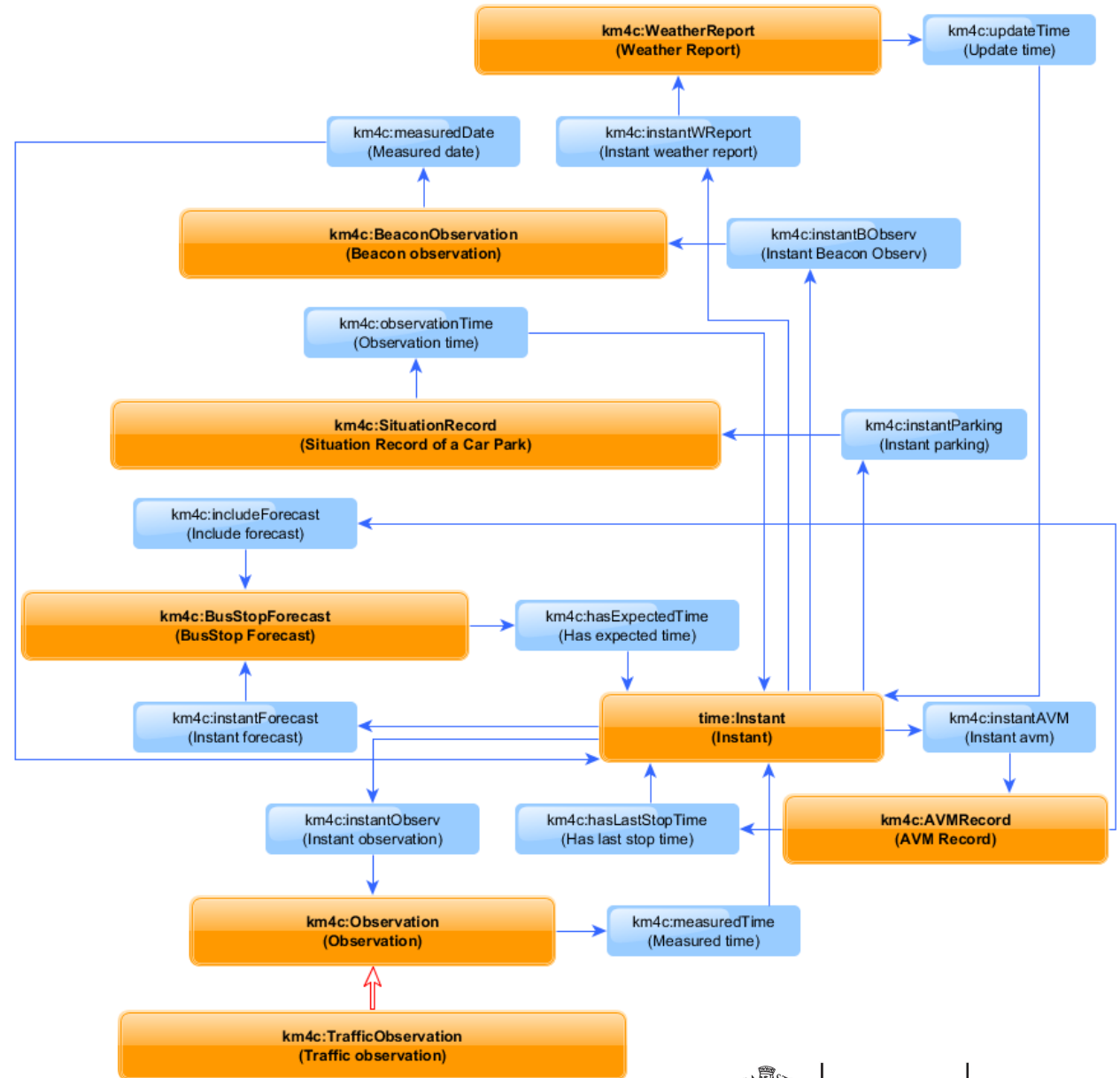
- SensorSiteTable
- SensorSite
- Road
- TrafficObservation
  - TrafficSpeed
  - TrafficFlow
  - TrafficHeadway
  - TrafficConcentration



# Km4City Ontology: Temporal domain (When Time Matters)

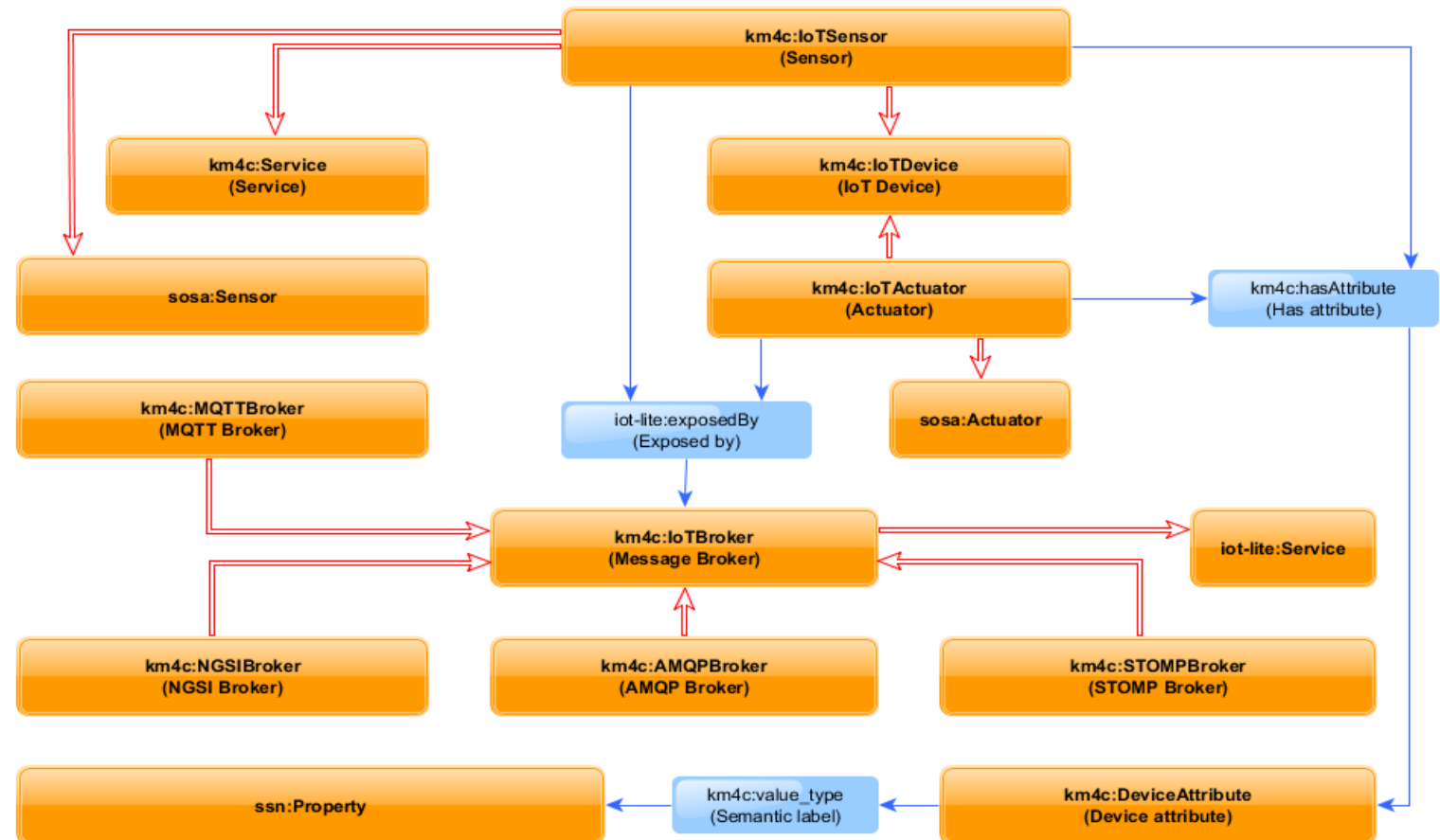
- It is the section of the Km4City Ontology where the most of the modelling of the real-time events/statuses can be found:

- Weather
- Parkings
- Public Transport
- Beacons



# Km4City Ontology: Internet of Things

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



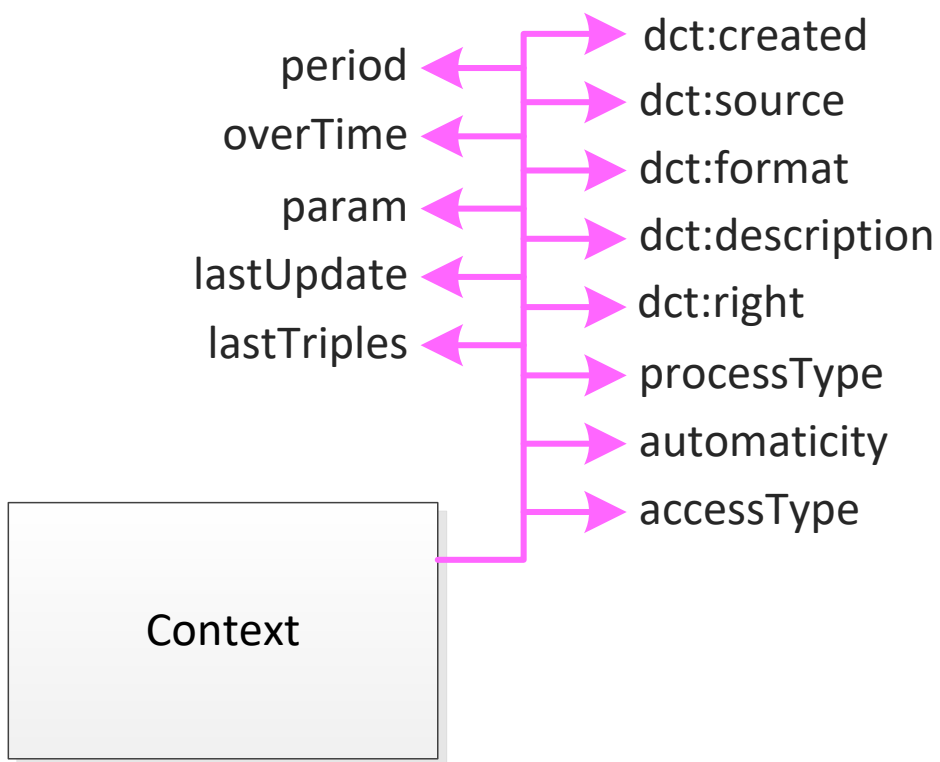


# Km4City Ontology: Contexts (Graphs)

- 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](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 Geofabrik (<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 optimize 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](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](https://postgis.net/docs/ST_AsText.html))
- **ST\_Centroid** - Computes the geometric center of a geometry  
([https://postgis.net/docs/ST\\_Centroid.html](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](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](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](https://postgis.net/docs/ST_Covers.html))
- **ST\_Distance** – Compute the distance between geometries or geographies. ([https://postgis.net/docs/ST\\_Distance.html](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](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](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](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](https://postgis.net/docs/ST_MakeLine.html))
- **ST\_MakePolygon** - Creates a Polygon formed by the given shell. ([https://postgis.net/docs/ST\\_MakePolygon.html](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](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](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](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
```





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**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.

## **Real-Time**

The reconstruction is updated after every new traffic sensor detection.

## **Unobtrusive**

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

## **General**

No simplistic assumption is made about the street graph.

## **Visual**

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

## **Dense**

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

## **Open**

Methods and software are made available under an open license.

## **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 growth 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:

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

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  $\Delta x$  long.
- The time is partitioned in intervals  $\Delta t$  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  $u_m^h = u(t_h, xm) = u(h\Delta t, m\Delta x)$  be a continuous function defined on  $(h, m)$ . Denote  $F$  the numerical flux. Then, the vehicular density results from:

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

# 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

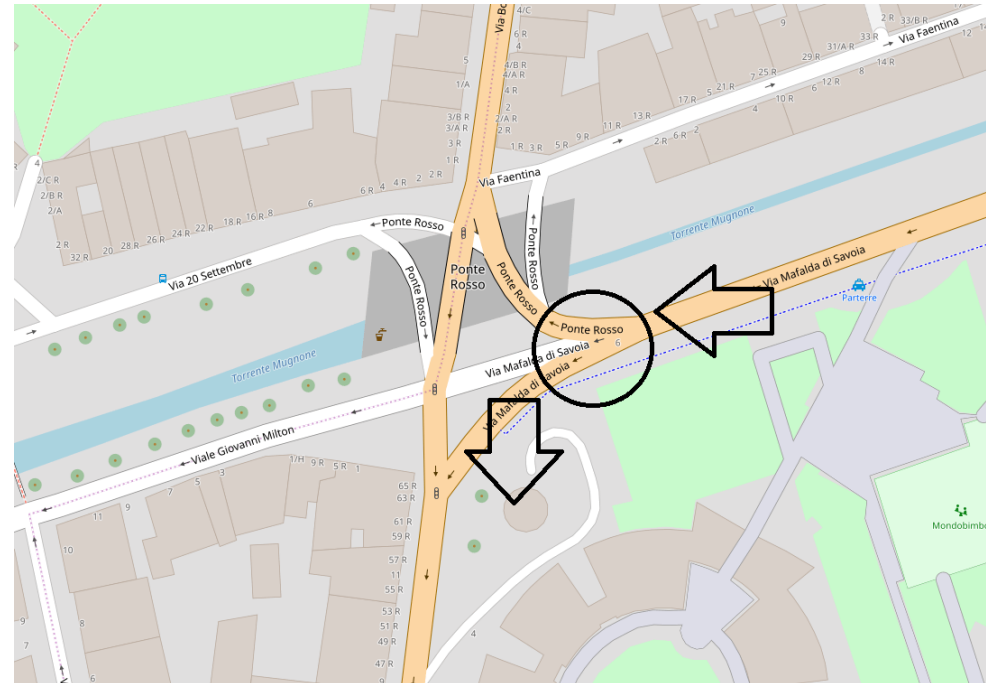
**Elem. Type:** T.O.C.

**Length:** 63

**Direction:** positive

...

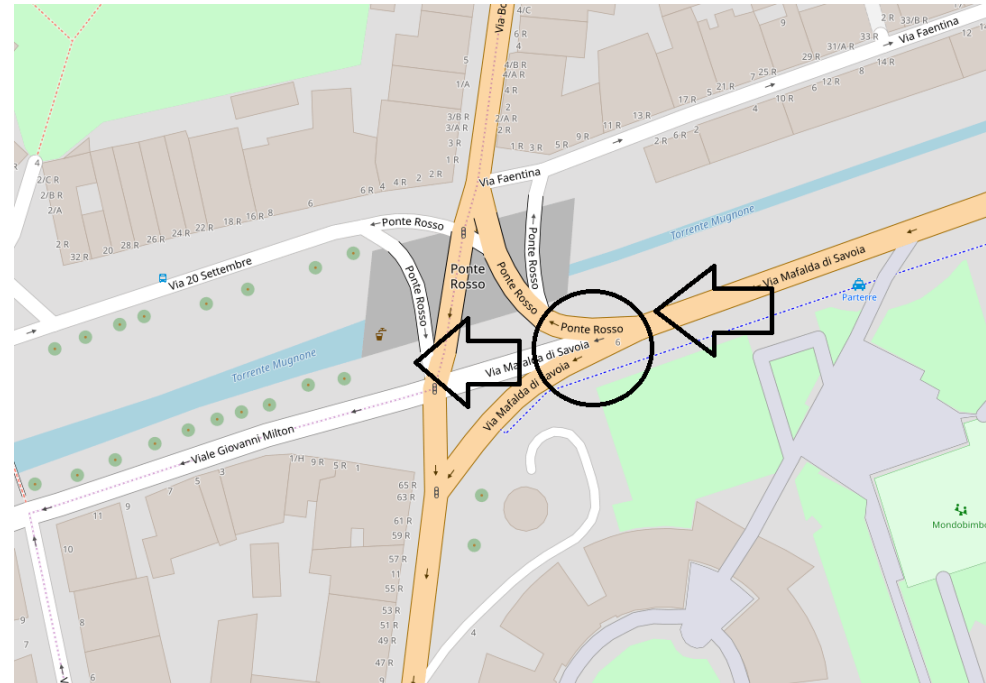
**Weight:** 31.122%





# 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**

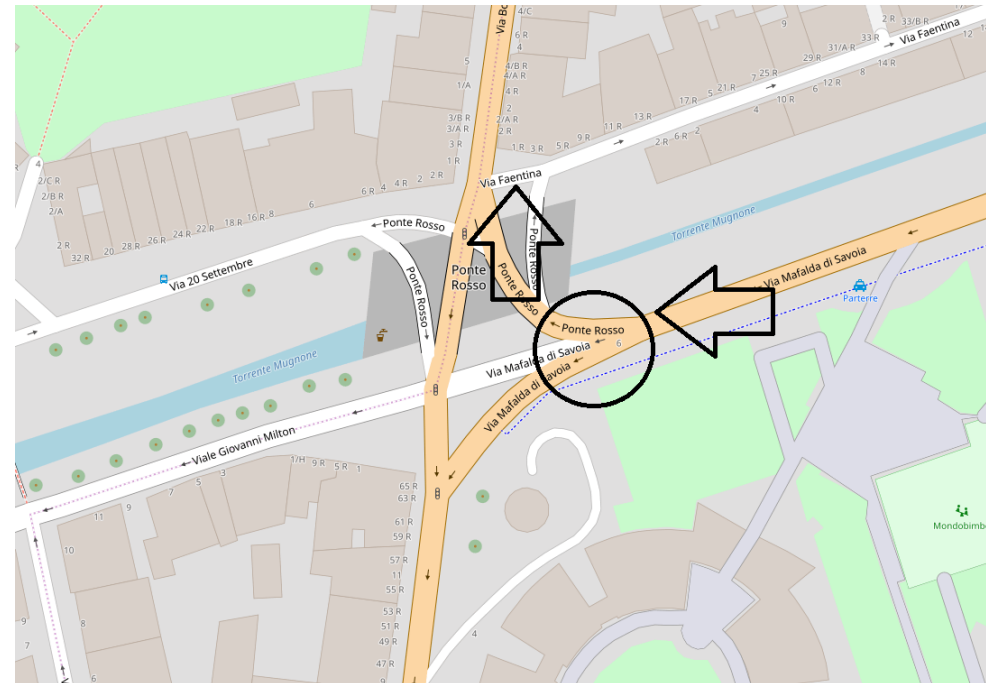
**Elem. Type: T.O.C.**

**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

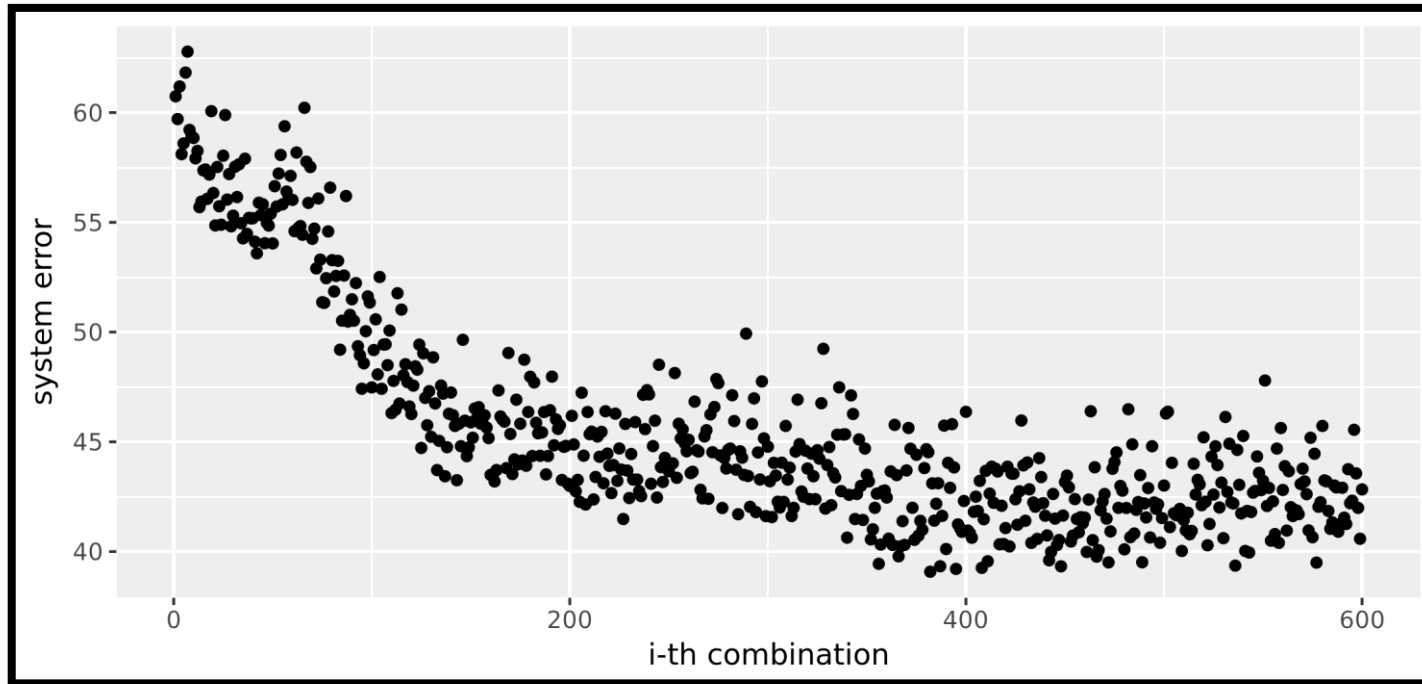
It has been observed that:

- 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.

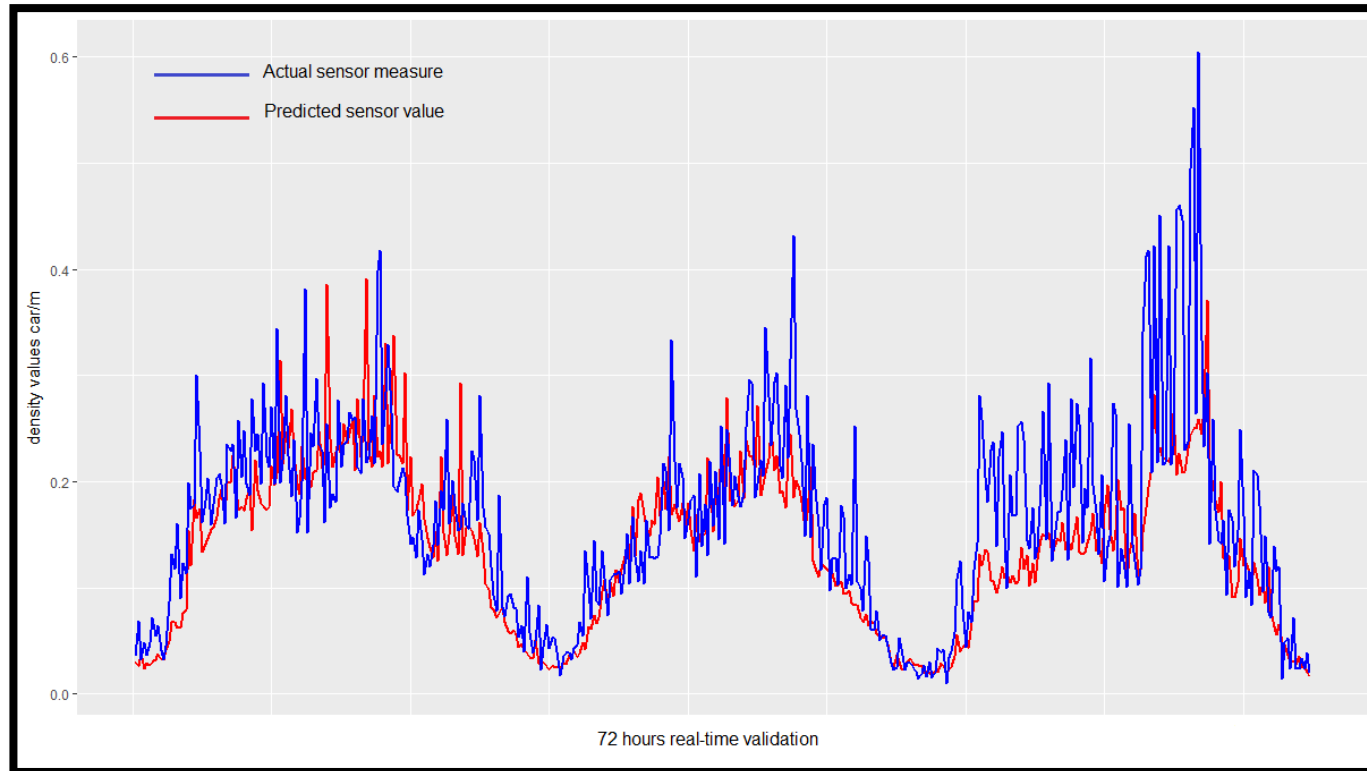
# Validation & Results

- 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.

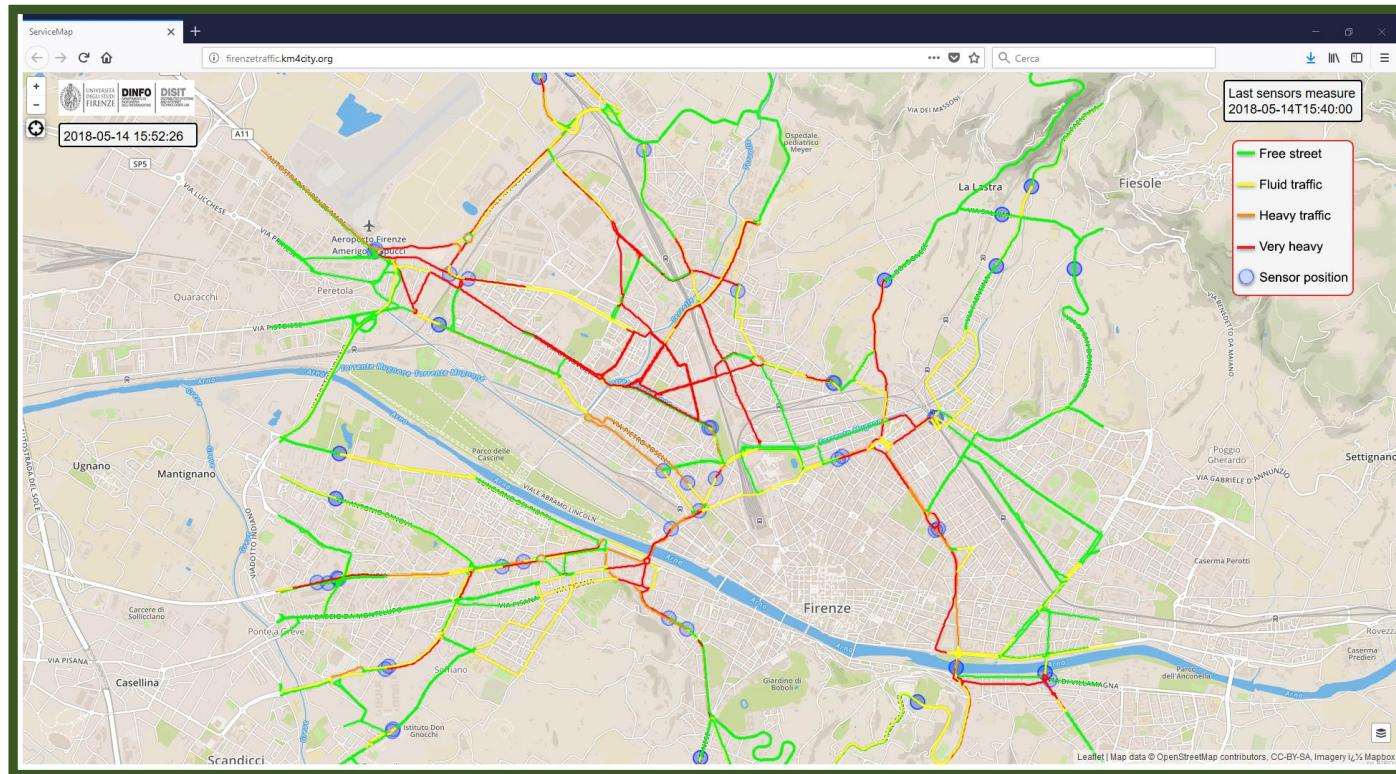
# Displaying of results

- 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	<a href="#">Triples Count Metric</a>
Endpoint	<a href="http://dblp.l3s.de/d2r/sparql">http://dblp.l3s.de/d2r/sparql</a>
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	<a href="http://dblp.l3s.de/d2r/sparql">http://dblp.l3s.de/d2r/sparql</a>
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	<a href="http://data.open.ac.uk/query">http://data.open.ac.uk/query</a>
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	<a href="http://dblp.l3s.de/d2r/sparql">http://dblp.l3s.de/d2r/sparql</a>
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	<a href="https://ruian.linked.opendata.cz/sparql">https://ruian.linked.opendata.cz/sparql</a>
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	<a href="#">Language Metric</a>
Endpoint	<a href="http://dbpedia.org/sparql">http://dbpedia.org/sparql</a>
Thread	disitms7
Duration	1532926116027
Completion	2018-07-31 13:58:55.0
Result	<pre>{   "status": "OK",   "result": {     "de": 2142932,     "hi": 35,     "pt": 626,     "it": 1,     "lv": 11,     "zh-cn": 407775,     "hu": 4, </pre>

- 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	<a href="#">Alive Endpoints</a>
Endpoint	All (Global Measure)
Thread	disitms3_4
Duration	1535558679817
Completion	2018-08-29 18:04:39.0
Result	<pre>{   "status": "OK",   "result": 185 }</pre>

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	<a href="#">Alive Endpoints Ratio</a>
Endpoint	All (Global Measure)
Thread	disitms3_4
Duration	1535558680251
Completion	2018-08-29 18:04:40.0
Result	<pre>{   "status": "OK",   "result": 30.478 }</pre>

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	<a href="#">Global Instance Count Metric</a>
Endpoint	All (Global Measure)
Thread	disitms3_4
Duration	1535558686995
Completion	2018-08-29 18:04:47.0
Result	<pre>{   "status": "OK",   "result": 1163441275 }</pre>

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	<a href="#">Average Instance Count Metric</a>
Endpoint	All (Global Measure)
Thread	disitms3_4
Duration	1535877788063
Completion	2018-09-02 10:43:08.0
Result	<pre>{   "status": "OK",   "result": 6288871.757 }</pre>

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	<a href="#">Class Ranking</a>
Endpoint	All (Global Measure)
Thread	disitms3_4
Duration	1535558901781
Completion	2018-08-29 18:10:28.0
Result	<pre>{   "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,</pre>

```
"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/affymatrix_vocabulary:Resource": 41046768,
"http://xmlns.com/foaf/0.1/Document": 40485549,
"http://bio2rdf.org/wormbase_vocabulary:Resource": 39231136,
"http://bio2rdf.org/affymatrix_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	<a href="#">Class Ratio</a>
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, ... } }

```
"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,
"http://www.w3.org/2000/01/rdf-schema#isDefinedBy": 67,
"http://www.w3.org/1999/02/22-rdf-syntax-ns#first": 65,
"http://www.w3.org/1999/02/22-rdf-syntax-ns#rest": 65,
"http://www.w3.org/2004/02/skos/core#Concept": 56,
"http://purl.org/dc/terms/creator": 56,
"http://xmlns.com/foaf/0.1/Organization": 52,
"http://www.w3.org/2004/02/skos/core#definition": 50,
"http://purl.org/dc/terms/contributor": 47,
"http://www.w3.org/2000/01/rdf-schema#Datatype": 45,
"http://www.w3.org/2000/01/rdf-schema#seeAlso": 45,
"http://purl.org/dc/terms/title": 43,
"http://purl.org/dc/terms/description": 42,
"http://www.w3.org/2004/02/skos/core#prefLabel": 42,
"http://xmlns.com/foaf/0.1/homepage": 41,
"http://www.w3.org/2004/02/skos/core#scopeNote": 41,
"http://purl.org/dc/terms/identifier": 41,
"http://xmlns.com/foaf/0.1/name": 40,
"http://www.w3.org/2000/01/rdf-schema#Resource": 40,
"http://purl.org/goodrelations/v1#Offering": 39,
"http://purl.org/goodrelations/v1#BusinessEntity": 38,
"http://xmlns.com/foaf/0.1/Agent": 38,
"http://purl.org/dc/terms/extent": 37,
"http://purl.org/goodrelations/v1#PriceSpecification": 37,
"http://www.w3.org/1999/02/22-rdf-syntax-ns#value": 37,
"http://purl.org/dc/terms/source": 35,
"http://purl.org/goodrelations/v1#ProductOrServicesSomeInstancesPlaceholder": 35,
"http://purl.org/goodrelations/v1#LocationOfSalesOrServiceProvisioning": 35,
"http://purl.org/dc/terms/Agent": 35,
```





# 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	<pre>{   "status": "OK",   "result": {     "http://www.w3.org/1999/02/22-rdf-syntax-ns#type": 73.617,     "http://www.w3.org/1999/02/22-rdf-syntax-ns#Property": 50.213,     "http://www.w3.org/2000/01/rdf-schema#Class": 46.383,     "http://www.w3.org/2000/01/rdf-schema#label": 42.128,     "http://xmlns.com/foaf/0.1/Person": 40,     "http://www.w3.org/2000/01/rdf-schema#comment": 35.319,     "http://purl.org/dc/terms/created": 34.894,</pre>

```
http://purl.org/dc/terms/modified": 34.043,
"http://www.w3.org/2000/01/rdf-schema#subClassOf": 31.915,
"http://www.w3.org/2000/01/rdf-schema#subPropertyOf": 31.064,
"http://www.w3.org/2000/01/rdf-schema#domain": 31.064,
"http://www.w3.org/2000/01/rdf-schema#range": 30.638,
"http://www.w3.org/2000/01/rdf-schema#isDefinedBy": 28.511,
"http://www.w3.org/1999/02/22-rdf-syntax-ns#first": 27.66,
"http://www.w3.org/1999/02/22-rdf-syntax-ns#rest": 27.66,
"http://www.w3.org/2004/02/skos/core#Concept": 23.83,
"http://purl.org/dc/terms/creator": 23.83,
"http://xmlns.com/foaf/0.1/Organization": 22.128,
"http://www.w3.org/2004/02/skos/core#definition": 21.277,
"http://purl.org/dc/terms/contributor": 20,
"http://www.w3.org/2000/01/rdf-schema#Datatype": 19.149,
"http://www.w3.org/2000/01/rdf-schema#seeAlso": 19.149,
"http://purl.org/dc/terms/title": 18.298,
"http://purl.org/dc/terms/description": 17.872,
"http://www.w3.org/2004/02/skos/core#prefLabel": 17.872,
"http://xmlns.com/foaf/0.1/homepage": 17.447,
"http://www.w3.org/2004/02/skos/core#scopeNote": 17.447,
"http://purl.org/dc/terms/identifier": 17.447,
"http://xmlns.com/foaf/0.1/name": 17.021,
"http://www.w3.org/2000/01/rdf-schema#Resource": 17.021,
"http://purl.org/goodrelations/v1#Offering": 16.596,
"http://purl.org/goodrelations/v1#BusinessEntity": 16.17,
"http://xmlns.com/foaf/0.1/Agent": 16.17,
"http://purl.org/dc/terms/extent": 15.745,
"http://purl.org/goodrelations/v1#PriceSpecification": 15.745,
"http://www.w3.org/1999/02/22-rdf-syntax-ns#value": 15.745,
"http://purl.org/dc/terms/source": 14.894,
"http://purl.org/goodrelations/v1#ProductOrServicesSomeInstancesPlaceholder": 14.894,
"http://purl.org/goodrelations/v1#LocationOfSalesOrServiceProvisioning": 14.894,
"http://purl.org/dc/terms/Agent": 14.894,
```



# 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](https://github.com/dcmi/repository/blob/master/wikis_pre2016/nkos/mediawiki/NKOS_Vocabularies.md)



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