Smart City data via LOD/LOG Service

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Slides for: LOD2014 event.

Research objectives

- **Why**: Create an ontology that allows to combine all data provided by the *city of Florence* and the *Tuscan region*.
- **Problems**: data have different formats, they must be reconciled in order to be effectively interconnected to each other, but sometimes information is incomplete.
- **Objective**: take advantage of the created repository and ontology to implement new integrated services related to mobility; to provide repository access to *SMEs* to create new services.

Analysis of Available Data

- 519 OpenData (Municipality of Florence)
- 145 OpenData (Tuscany Region)
- LPT Timetable and LPT Route
- Street Graph
- Points of Interest
- Real Time Data from traffic sensors
- Real Time Data from parking sensors
- Real Time Data from AVM systems
- Weather Forecast (consortium Lamma)

DataSet already integrated

- From MIIC web services (real time)
  - Parking payloadPublication (updated every h)
  - Traffic sensors payloadPublication (updated every 5-10min)
  - AVM client pull service (updated every 24h)
  - Street Graph
- From Municipality of Florence:
  - Tram line: KMZ file that represents the path of tram in Florence
  - Statistics on monthly access to the LTZ, tourist arrivals per year, annual sales of bus tickets, accidents per year for every street, number of vehicles per year
  - Municipality of Florence resolutions
- From Tuscany Region:
  - Museums, monuments, theaters, libraries, banks, courier services, police, firefighters, restaurants, pubs, bars, pharmacies, airports, schools, universities, sports facilities, hospitals, emergency rooms, doctors' offices, government offices, hotels and many other categories
  - Weather forecast of the consortium Lamma (updated twice a day)

Ontology' Macroclasses

- **Maps and Geographical information**: formed by classes *Road, Node, RoadElement, AdministrativeRoad, Milestone, StreetNumber, RoadLink, Junction, Entry,* and *EntryRule, Manoeuver*, is used to represent the entire road system of Tuscany region.
- **Point of Interest**: economical services (public and privates), activities, which may be useful to the citizen and who may have the need to search for and to arrive at. Classification will be based on the division into categories planned at regional level.
- **Weather**: including *status* and *forecasts* from the consortium Lamma in Tuscany.

Ontology' Macroclasses

- **Transport**: data coming from major LPT companies including scheduled times, the rail graph, data relating to real time passage at bus stops. *Classes*: *bus line, Ride, Route, record, RouteSection, BusStopForeast, RouteLink*.
- **Sensors**: concerning data coming from sensors; they may include information such as *pressure, humidity, pollution, car flow, car velocity, number of passed cars* and tracks, etc.
- **Administration**: includes information coming from public administrations such as *resolutions* issued by each administration, *planned events, changes in the traffic arrangement, planned VIP visits, sports events*, etc.

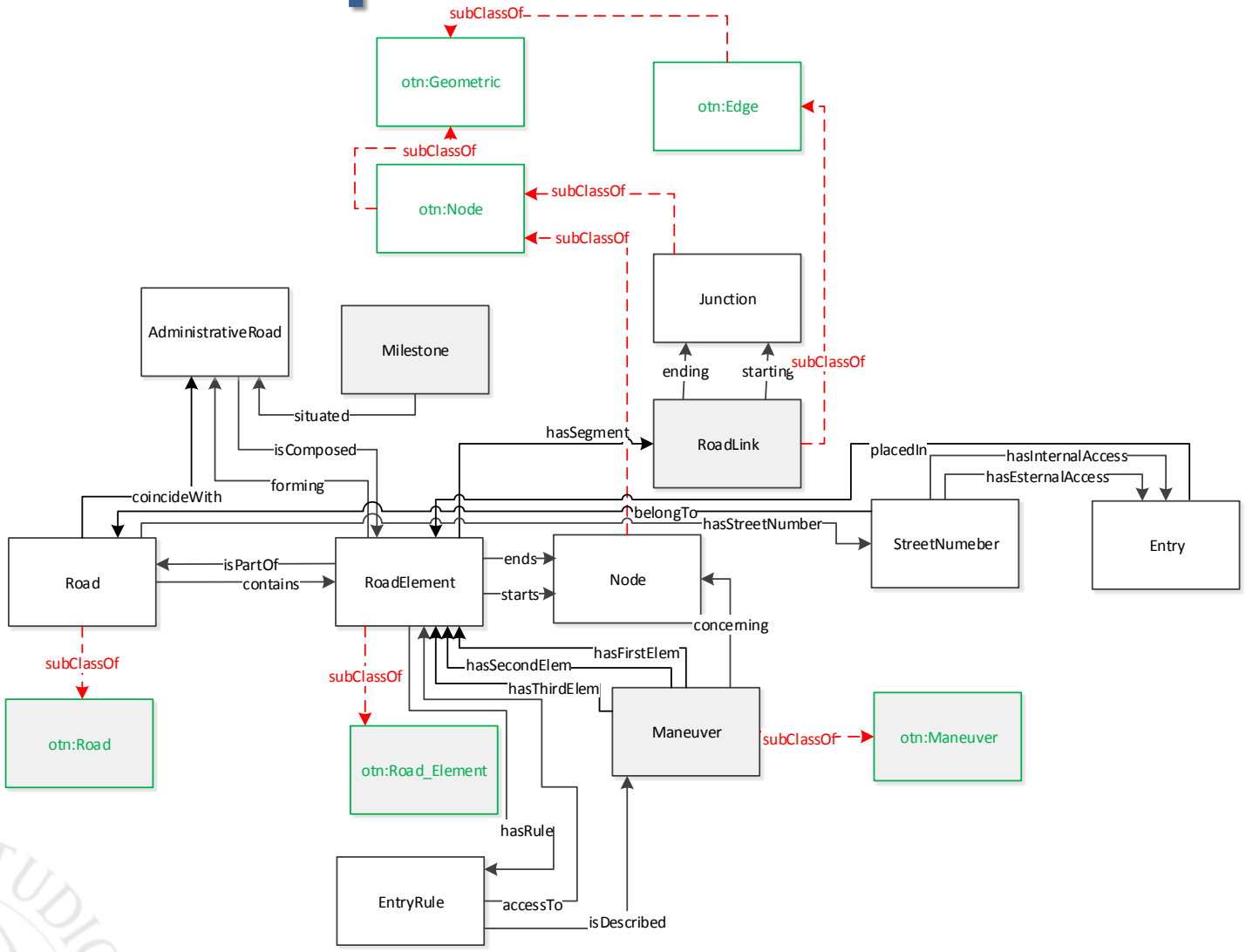
Maps Macroclass

- **RoadElement**: delimited by a start node and an end node (ObjectProperties "starts" e "ends");
- **Road**: composed by RoadElement and Node ("contains")
- **AdministrativeRoad**: connected to RoadElement (“isComposed” e “forming”), to Road (“coincideWith”). *Road : AdministrativeRoad = N:M*. Both in a 1:N relation with RoadElement;
- **EntryRule**: connected to RoadElement ("hasRule", "accessTo ");
- **Maneouvre**: linked to EntryRule ("isDescribed"). Described through "hasFirstElem", "hasSecondElem" and "hasThirdElem". "concerning" fastes a maneouvre to the concerned junction.

Maps Macroclass

- **Node**: georeferenced through geo:lat and geo:long.
- **Milestone**: associated with 1 AdministrativeRoad ("placedIn"), georeferenced through geo:lat and geo:long.
- **StreetNumber**: always related to at least 1entry (internal or external). Connected to RoadElement and Road ("standsIn" and "belongTo"); reverse:"hasStreetNumber".
- **Entry**: connected to StreetNumber through "hasInternalAccess" and "hasExternalAccess", with cardinality restrictions, subclass of geo:SpatialThing, maximum cardinality restriction 1 to geo:lat and geo:long
- "ownerAuthority" and "managingAuthority": linked to *PA macroclass.*

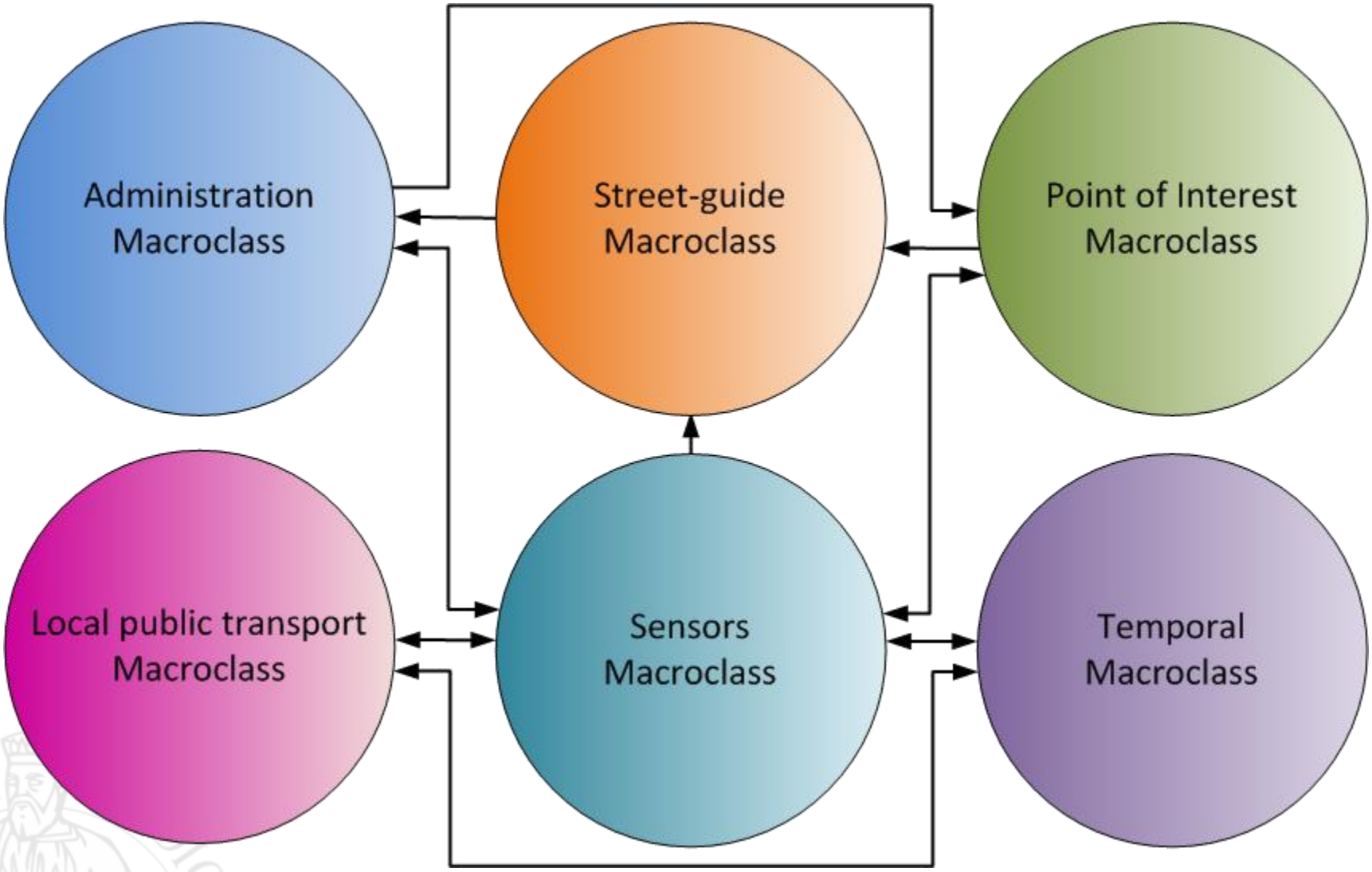
Maps Macroclass

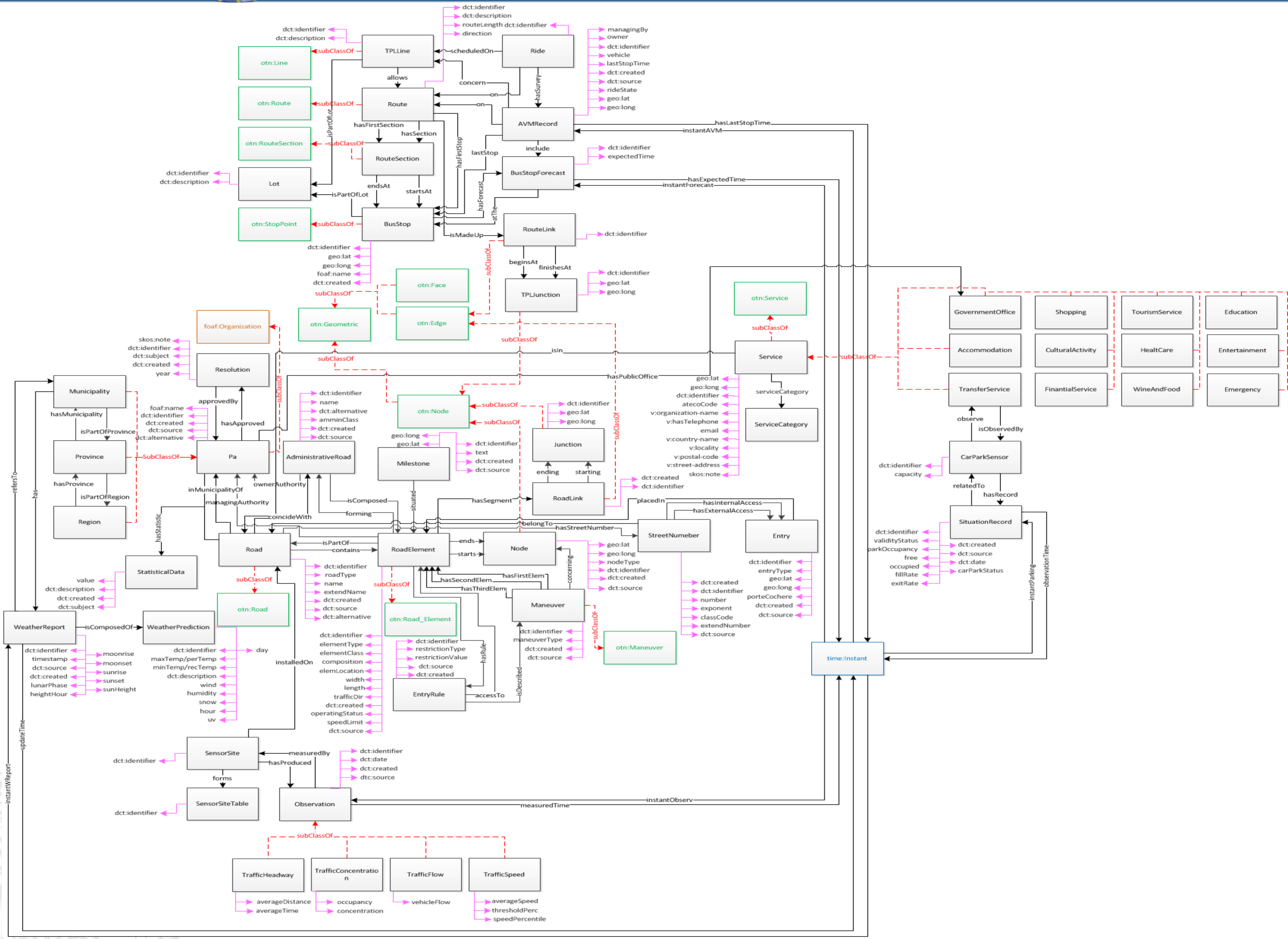


Reused Vocabulary

- ***OTN:*** *an ontology of traffic networks that is* more or less a direct encoding of GDF (Geographic Data Files) in OWL;
- ***dcterms:*** *set of properties* and classes maintained by the Dublin Core Metadata Initiative;
- ***foaf:*** *dedicated to the description of* the relations between people or groups;
- ***vCard:*** *for a description of people and organizations;*
- ***wgs84_pos:*** *vocabulary representing latitude and longitude, with the WGS84 Datum, of geo-objects.*

Macroclasses' Connections




TPLLine
Ride
Route
AVMRecord
RouteSection
BusStopForecast
Lot
BusStop
RouteLink
TPLJunction
otn:Line
otn:Route
otn:RouteSection
otn:StopPoint
otn:Face
otn:Edge
otn:Geometric
otn:Node
otn:Service
foaf:Organization
Resolution
Municipality
Province
Region
Pa
AdministrativeRoad
Milestone
Junction
RoadLink
Service
ServiceCategory
GovernmentOffice
Shopping
TourismService
Education
Accommodation
CulturalActivity
HealtCare
Entertainment
TransferService
FinantialService
WineAndFood
Emergency
CarParkSensor
SituationRecord
StatisticalData
Road
RoadElement
Node
StreetNumeber
Entry
otn:Road
otn:Road_Element
Maneuver
otn:Maneuver
EntryRule
time:Instant
WeatherReport
WeatherPrediction
SensorSite
SensorSiteTable
Observation
TrafficHeadway
TrafficConcentration
TrafficFlow
TrafficSpeed
subClassOf
scheduledOn
allows
concern
on
hasSurvey
hasFirstSection
hasSection
include
lastStop
hasFirstStop
isPartOfLot
endsAt
startsAt
hasForecast
atThe
isMadeUp
beginsAt
finishesAt
hasLastStopTime
instantAVM
hasExpectedTime
instantForecast
isIn
hasPublicOffice
serviceCategory
observe
isObservedBy
relatedTo
hasRecord
approvedBy
hasApproved
hasMunicipality
isPartOfProvince
hasProvince
isPartOfRegion
inMunicipalityOf
ownerAuthority
managingAuthority
coincideWith
isComposed
forming
situated
hasSegment
ending
starting
placedIn
hasInternalAccess
hasExternalAccess
belongTo
hasStreetNumber
isPartOf
contains
ends
starts
hasSecondElem
hasFirstElem
hasThirdElem
concerning
hasRule
accessTo
isDescribed
refersTo
has
hasStatistic
isComposedOf
installedOn
measuredBy
hasProduced
forms
instantObserv
measuredTime
updateTime
instantWReport
instantParking
observationTime
dct:identifier
dct:description
routeLength
direction
managingBy
owner
vehicle
lastStopTime
dct:created
dct:source
rideState
geo:lat
geo:long
expectedTime
foaf:name
skos:note
dct:subject
year
dct:alternative
name
amminClass
text
atecoCode
v:organization-name
v:hasTelephone
email
v:country-name
v:locality
v:postal-code
v:street-address
capacity
validityStatus
parkOccupancy
free
occupied
fillRate
exitRate
dct:date
carParkStatus
entryType
porteCochere
number
exponent
classCode
extendNumber
nodeType
roadType
extendName
elementType
elementClass
composition
elemLocation
width
length
trafficDir
operatingStatus
speedLimit
restrictionType
restrictionValue
maneuverType
value
timestamp
lunarPhase
heightHour
moonrise
moonset
sunrise
sunset
sunHeight
maxTemp/perTemp
minTemp/recTemp
day
wind
humidity
snow
hour
uv
dtc:source
averageDistance
averageTime
occupancy
concentration
vehicleFlow
averageSpeed
thresholdPerc
speedPercentile

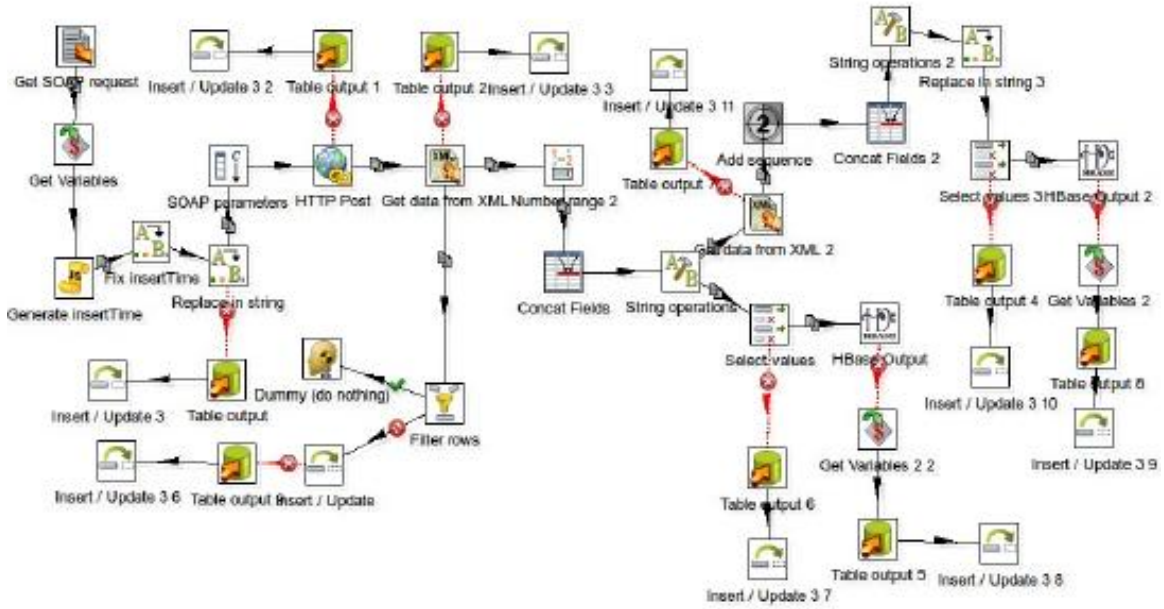
From Open Data to Triples

- **Phase 1**: collect data from different sources (MIIC Web Service, Osservatorio dei Trasporti e della Mobilita' portal, Municipality of Florence and Tuscany Region Web Sites).
- **Phase 2**: first processing means ETL tool and NoSQL database storage.
- **Phase 3**: second transformation using ETL tools and RDF triples creation.
- **Phase 4**: Saving triple in RDF store.

Helpful Tools

- ETL Trasformation

kettle™ pentaho data integration

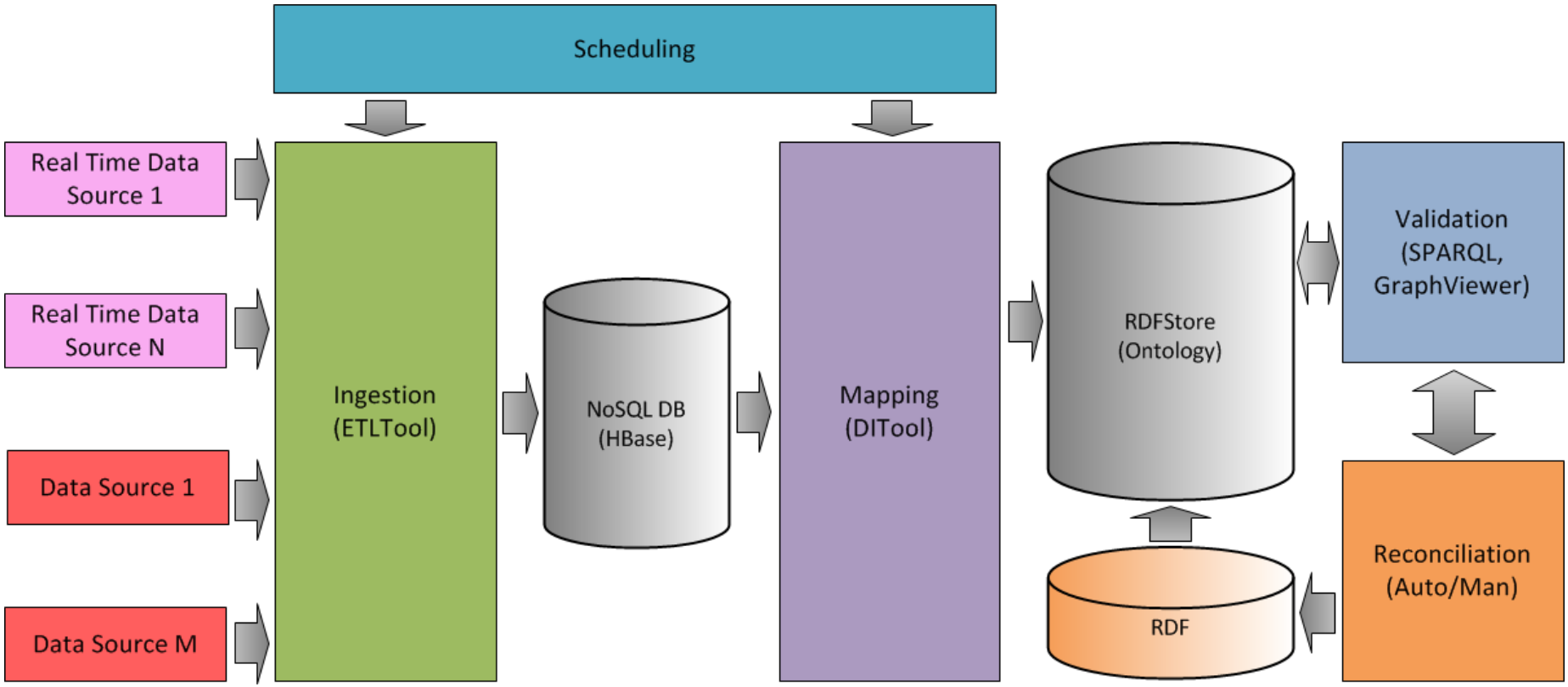


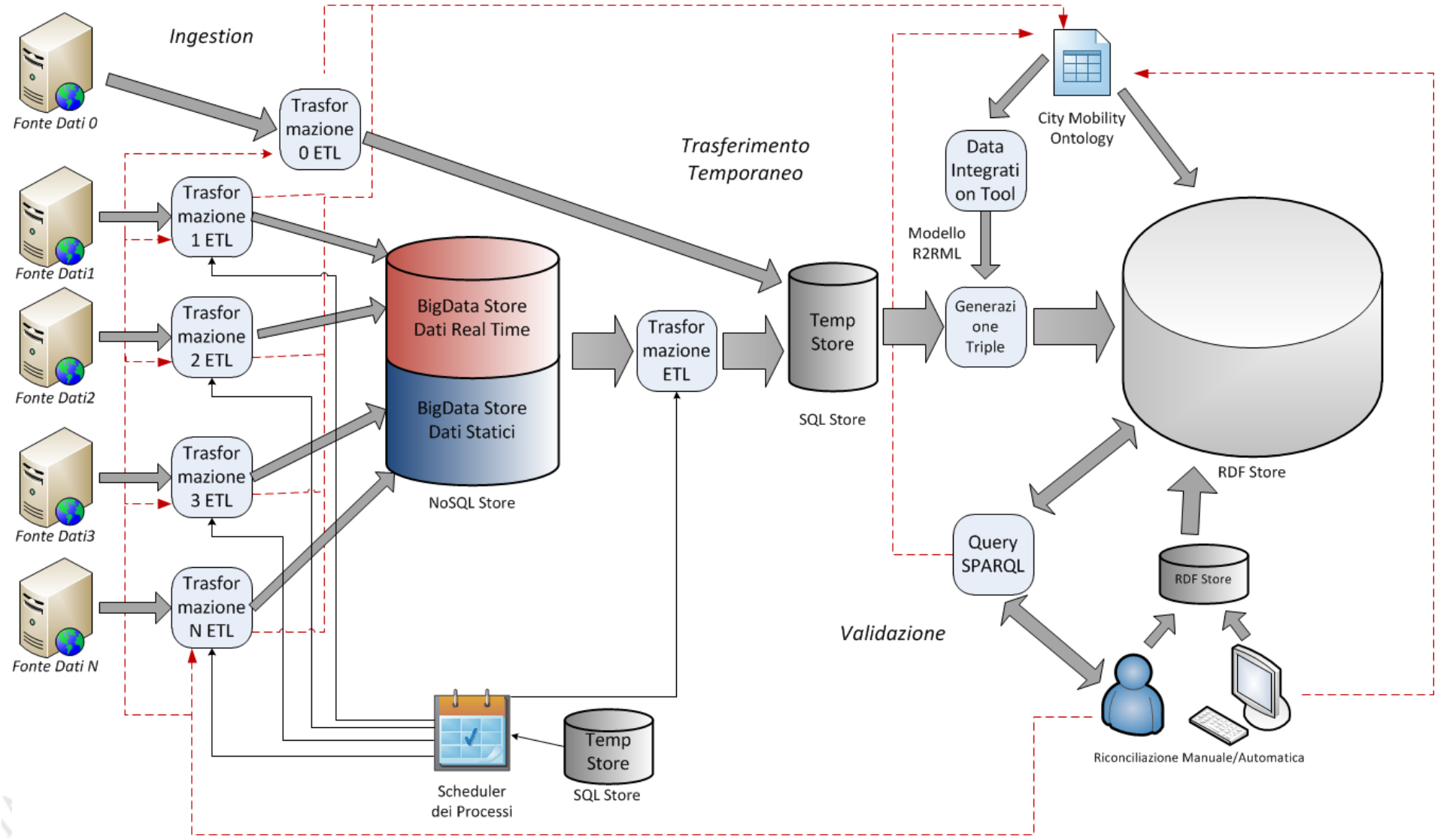
- To realize the R2RML model **Karma v1.110**
- RDF Store OWLIM

Architecture

- To automate the different phases, we have created an **architecture** that includes a **process scheduler**.
- The process scheduler implementation was necessary **to repeat the 4 phases**, from ingestion to transformation in triple.
- We storing data in Hbase according to a programmed rate, which is closely linked to the type of data (static/real time):
  - Real-time data: every 10min;
  - Other data: 2 - 15 times a day;
  - Static data: once a month or more.

Architecture' Block Diagram




Ingestion
Fonte Dati 0
Fonte Dati1
Fonte Dati2
Fonte Dati3
Fonte Dati N
Trasformazione 0 ETL
Trasformazione 1 ETL
Trasformazione 2 ETL
Trasformazione 3 ETL
Trasformazione N ETL
BigData Store Dati Real Time
BigData Store Dati Statici
NoSQL Store
Trasferimento Temporaneo
Trasformazione ETL
Temp Store
SQL Store
City Mobility Ontology
Data Integration Tool
Modello R2RML
Generazione Triple
RDF Store
Query SPARQL
RDF Store
Validazione
Riconciliazione Manuale/Automatica
Scheduler dei Processi
Temp Store
SQL Store

Data Validation & Reconciliation

- Major problems with the data:
  - inconsistent data (different municipality to the same service, city names that are not a municipality)
  - missing data (street number)
  - incorrect data (spelling errors)
- Need to validate the data, but above all to reconcile them to be able to connect with each other:
  - Service – Street Name Reconciliation
  - Service – Coordinate Reconciliation

Reconciliation Numbers

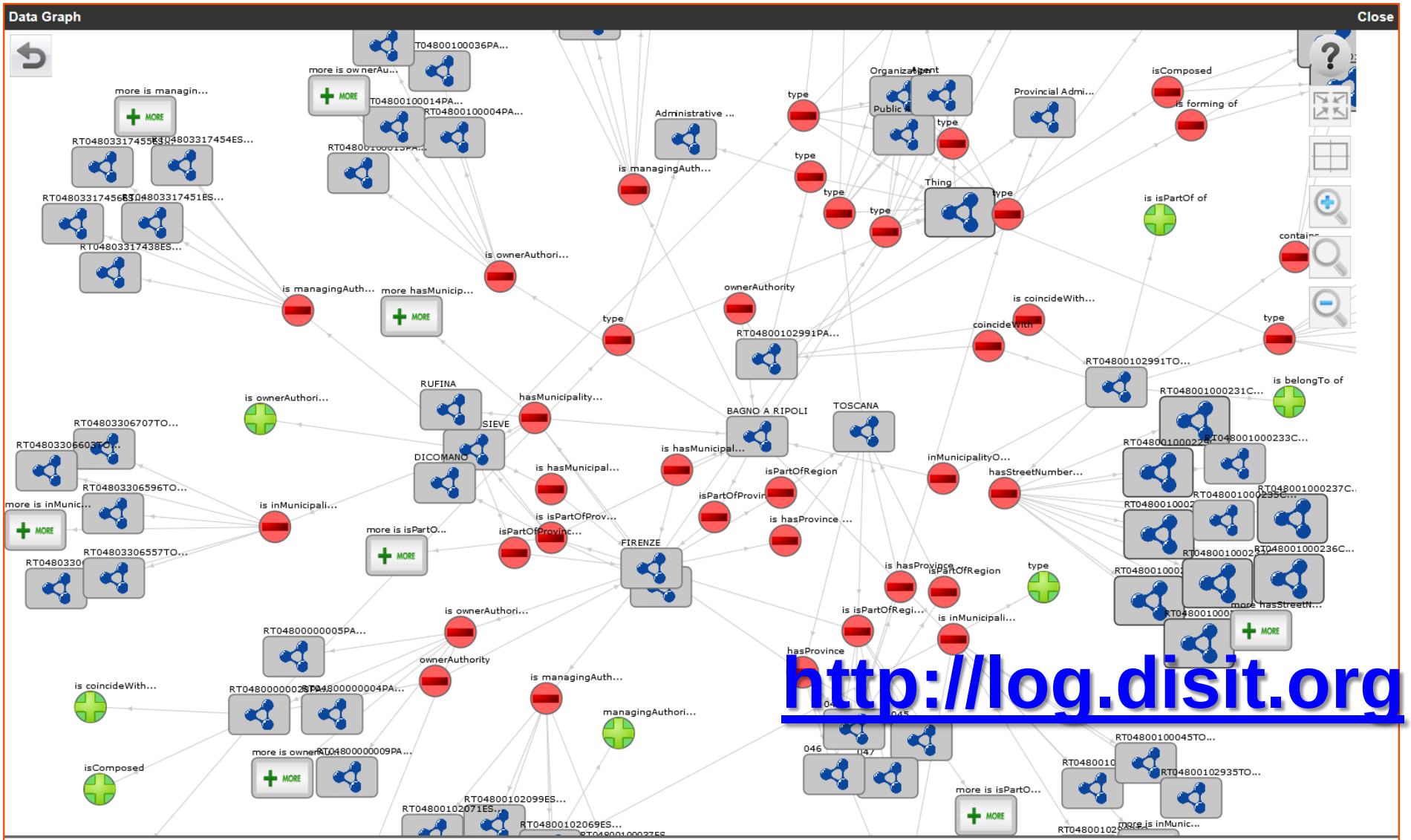
- **Services**: ~ 30.100 (all over Tuscan region) of which:
  - *Geolocalized* Services: ~ 12.400
  - Services *located at street level*: ~ 8.300
- **Remaining Services**: ~ 9.000 of which:
  - *Non-unique results* to locate the service at street level
  - Street Number *missing*
  - *Unusual letters* in municipality names or street names
  - Address *does not exist* on Street Graph: ~ 2.200 (next step: use the Google geocoding API)

Real Time Data Numbers

- **Weather**: 286 files uploaded twice a day → 270,000 Hbase rows/month → **~4 million triples/month**;
- **Sensors**: 126 active sensors → 18.000 Hbase rows/day, 50 supervised parking → **~10GB/month**;
- **Street Graph**: 68M triples.
- **For an amount of ~ 80MTriples** on repository

App Examples

- **Linked Open Graph (LOG)**: a tool developed to allow exploring semantic graph of the relation among the entities. It can be used to access to many different LOD repository. (http://log.disit.org/)
- **Maps**: service based on OpenStreetMaps that allows to search services available in a preset range from the selected bus stop. (http://servicemap.sii-mobility.org/)


Data Graph
Close
http://log.disit.org
Type of relations
Select all
Deselect all
Invert
sameAs
depiction
seeAlso
type
contains
coincideWith
inMunicipalityOf
hasStreetNumber
is isPartOf of
is belongTo of
ownerAuthority
isComposed
is forming of
isPartOfProvince
is managingAuthority of
is hasMunicipality of
isPartOfRegion
is hasProvince of
ends
starts
is placedIn of

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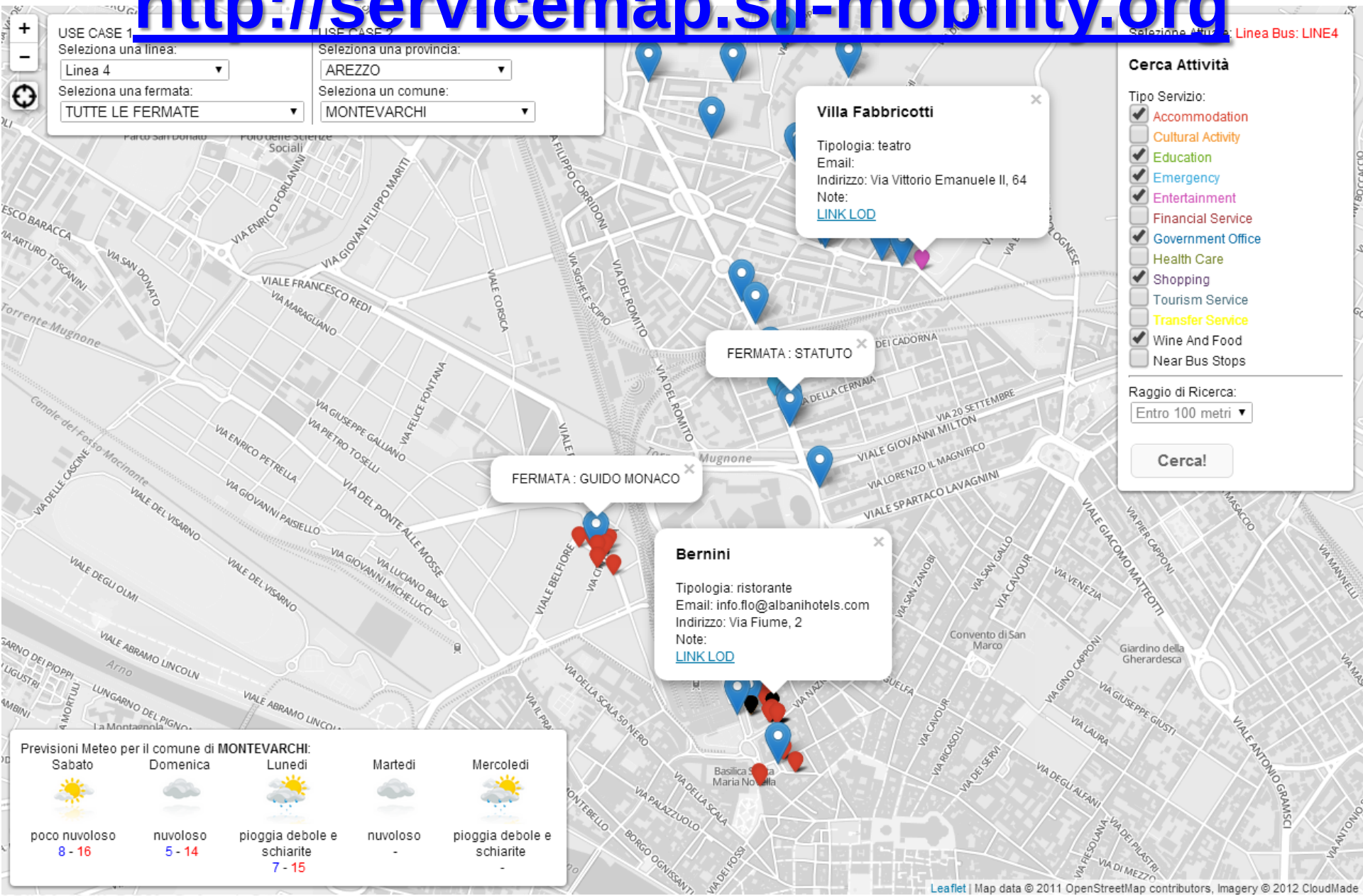
http://servicemap.sii-mobility.org



Future Works

- Integration of rail graph into the ontology;
- Insertion of other static datasets from the municipality of Florence and other Tuscany PA;
- Using Google Geocoding API to finish services reconciliation;
- Improvement of services' list and their geolocation;
- Creation of other apps that suggest to SME and PA how to use data.


THANK YOU
GRACIAS
ARIGATO
SHUKURIA
JUSPAXAR
GOZAIMASHITA
EFCHARISTO
KOMAPSUMIDA
MAAKE
GRAZIE
MEHRBANI
PALDIES
SUKSAMA
EKHMET
TASHAKKUR ATU
YAQHANYELAY
DANKSCHEEN
SHUKRIA
BÏYAN
TINGKI
BOLZÏN
MERCI