Extension and Contextualization for Linked Semantic 3D Geodata

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Aims

Apply the linked data principles to 3D geodata

Propose methodologies and design patterns for remaining issues

1. Model interconnection and extension

2. Representation of additional dimensions
time, LOD, confidence level, provenance, etc.

Linked geodata

Linked data

A set of principles defined to identify and publish data on the web

Linked geodata

Available datasets,
more often in 2D than in 3D

Example (adjacent figure),
issued from
https://www.geo.admin.ch/en/geo-services/geo-services/linkeddata.html

Available datasets

The following datasets of the Federal Spatial Data Infrastructure are currently available as Linked Data:

Title	Description
swissBOUNDARIES 3D	The administrative units and national boundaries of Switzerland and the Principality of Liechtenstein. Details
Public transport stops	Public transport stops in Switzerland, as well as other locations of operational or structural importance in public transportation (Operating points). Details

Linked 3D geodata?

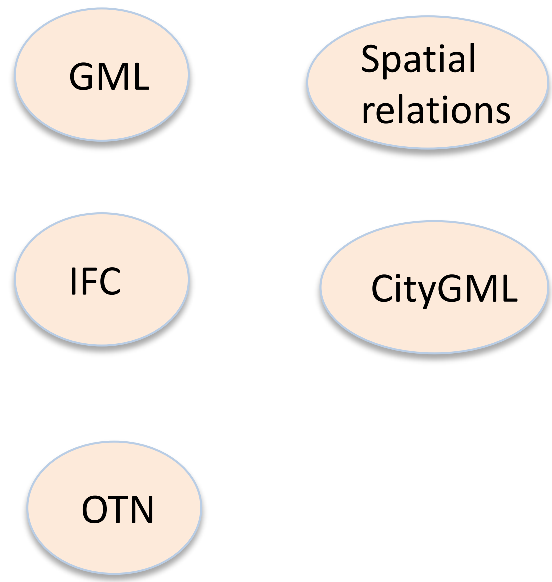
Available vocabularies

- Either in RDFS
  or in OWL (ontologies)
- At different levels:
  geometry and topology,
  building, city…

Available query languages

- SPARQL
- geoSPARQL

Some ontologies in OWL



1. Model interconnection or extension

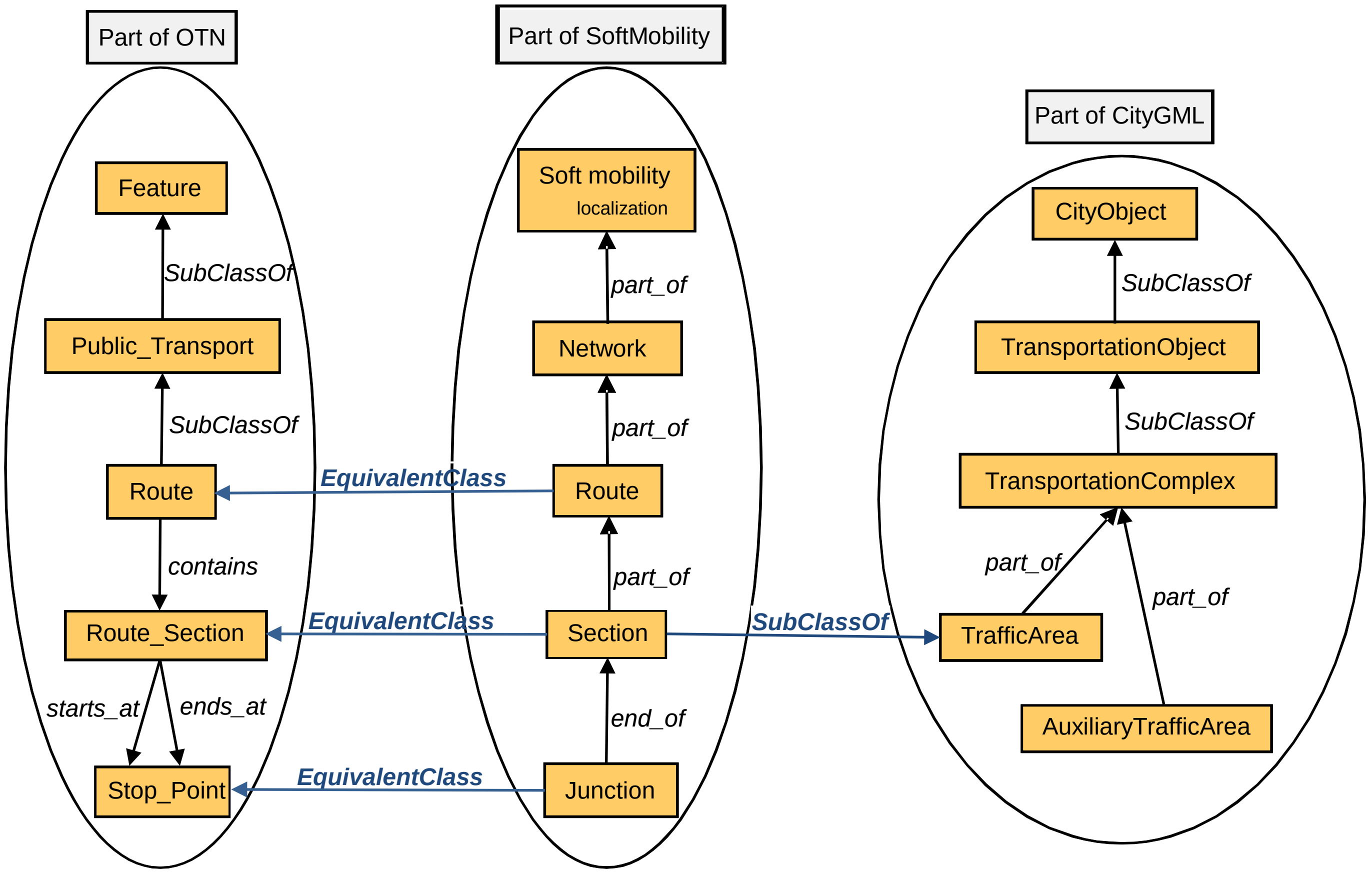
Goal

Provide a **unified view** of two or more data models that represent different aspects of the real world, that are related

Solution

- Simple (direct) connection statements using the following **axioms**
  SubClassOf,
  EquivalentClass,
  DisjointClass,
  sameAs
- Complex connection statements using logical expressions (axioms)
- **Query language** that supports RDFS/OWL inference, such as SPARQL-DL

Model interconnection: a simple example



By RDFS/OWL inference, obtention of a global model (unified view)

Model extension

Method

- Define additional classes and properties
- Define additional axioms to specify these classes and properties and their relationships with the initial model

Example

SolarPotential extension of the CityGML model (building) representing that a solar potential relates to one building:

sol:SolarPotential ***a*** *owl:Class .*
sol:ofBuilding ***a*** *owl:ObjectProperty .*
sol:SolarPotential ***rdfs:subClassOf*** *(sol:ofBuilding* ***exactly 1*** *bldg:Building) .*

Extension management

Conservative extension requirement

- The axioms in the extension must not modify the semantics of the basic model (example in the paper)
- Difficult to check:
  -> **restrict** the kind of axioms that can be used in an extension ontology

Multiple extension consistency

- The resulting global model must be consistent as are the different source models
- Easy to check on the global model (ontology) with an RDFS/OWL **reasoner**

2. Representation of additional dimensions

Main characteristics of linked data

- They are published on the web which is not a centrally controlled or curated environment
  -> confidence or provenance is a useful additional dimension

Possible additional dimensions

- Time, eg validity time, since the published data can evolve over time
- Level of Detail (LOD)
- Confidence, generally depending on the provenance

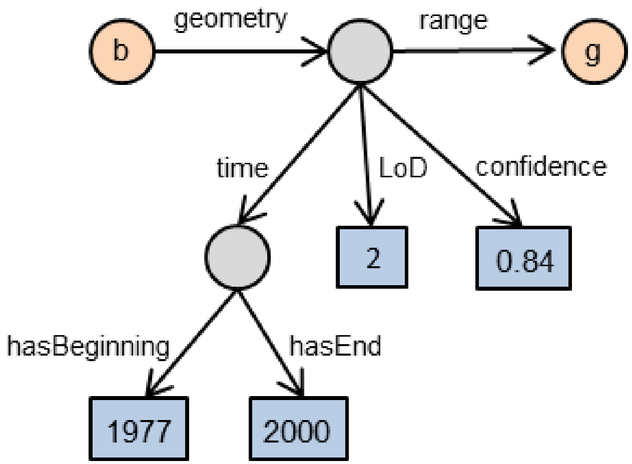
Proposition of a nD pattern

Simple triple approach

Building b has a geometry g

nD pattern approach

Building b has a geometry g with a level of detail 2 from 1977 to 2000, with a confidence value of 0.84



Proposition of a nD pattern

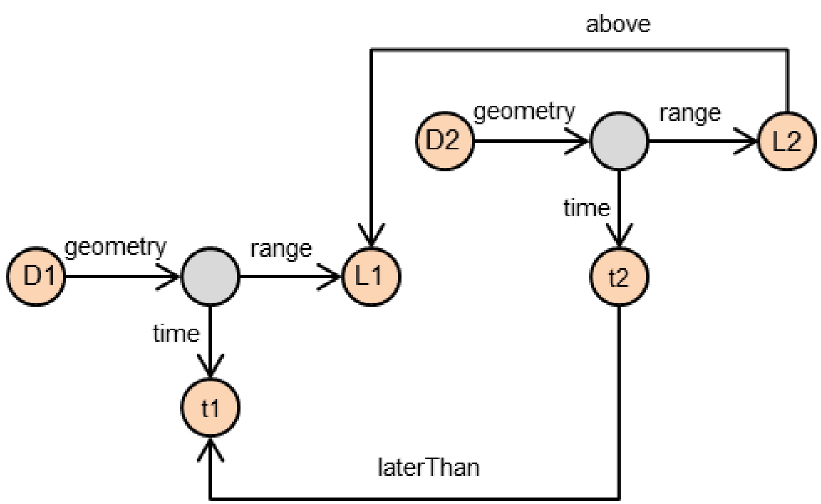
Time

- Can be **any time representation**, such as archeological time
- Example of a **stratigraphic time** representation:

  t2 = creation of deposit D2 (associated to layer L2)

  t1 = creation of deposit D1 (associated to layer L1)

  t2 later than t1 and L2 above L1



nD reasoning and operations

Snapshot

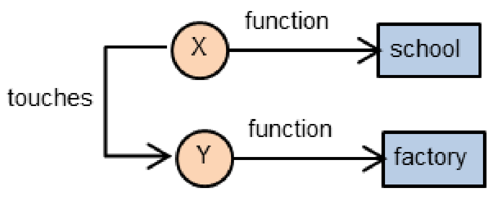
- Given a value for a dimension, retain only the facts that are true for this fixed dimension
- Is in fact a **projection** for the selected dimension
  - Project on the value 1977 for the validity time dimension
  - Project on IGN for the provenance dimension
  - Project on LoD2 for the LOD dimension
- Can be done using the SPARQL *CONSTRUCT* query form with the *FILTER* function
  - To construct a new graph containing only the facts that are true, eg for time=1977 (filter on this time value)

nD reasoning and operations

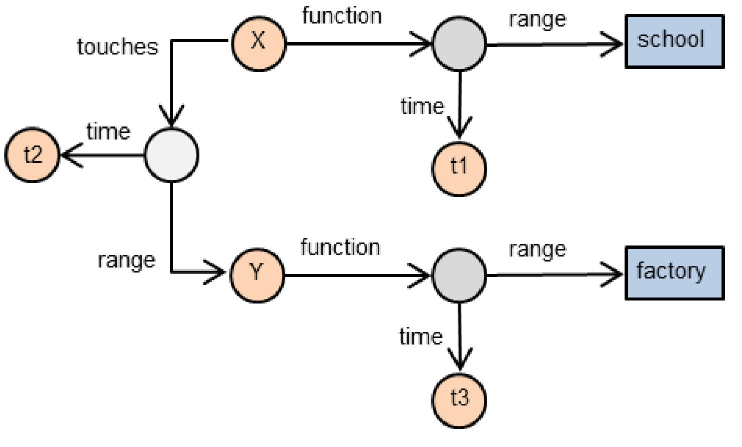
Context-aware queries

- Take in account some elements that are not in the initial query
- Example: what are the buildings X whose function is school and that touch a building Y whose function is factory?
  -> take time in account in order to represent that a building can evolve over time, either for its function or its form

Initial query



Effective query taking time in account



t1, t2 and t3 must have a common part

Conclusion and Future Work

To conclude

- The linked data principles are usable but not sufficient to create a Semantic Web of linked 3d geodata

- Two important issues were investigated
  - The management of 3D model extensions
  - The creation of nD models

- **Management of 3D model extensions**
  - Proposition of a modular solution based on ontology interconnection
  - Use of a reasoner for validating the global consistency of multiple extensions

Conclusion and Future Work

To conclude

- **Creation of nD models**
  - Proposition of a **nD pattern** that can support
    - any number of dimensions and
    - any type of dimension
      (linear validity time, archaeological time, provenance, LOD, etc.)
  - Ability to implement **nD reasoning** on the proposed nD pattern with the standard (geo)SPARQL language

To do

- Develop tools to **automate** the proposed approaches