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Semantic Spatial Data Infrastructures in Action

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Motivation

The geographic feature is managed differently in the Semantic Web and the Geospatial Web. The first community treats geographic features as the additional contextual information, which might link to some other concepts. For the Geospatial Web, the concept of geographic feature is the core element of a geographic platform. However, the Geospatial Web has focused on the interoperability issues maintaining the boundaries among the concepts from different geographic sources.

This work presents how approaches from the Semantic Web might be used for the improvement of functionality in a Spatial Data Infrastructure (SDI) and the user applications built on it. One of the pointed issues is the usage of a semantic reference to a geographic feature to identify geographic extent of a service or dataset. Supported by an appropriate backbone infrastructure, this meaningful information can be employed to reason on spatio-logical dependences among features and provide access to a better spatial object than the commonly applied minimum bounding box. The semantic service catalog deployed in SDI of Spain is presented as an example of the application where usage of semantics would improve the recall of catalog queries.

Linking Geographic Features: State of Art

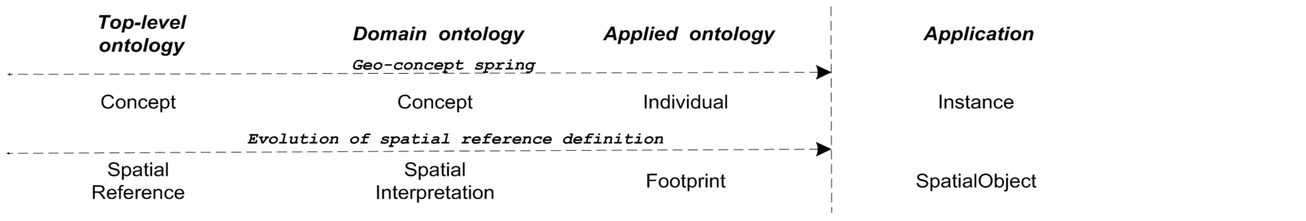
Semantic Web

- Geographic features as contextual part of Linked Data datasets, e.g., DBPedia.
- LinkedGeoData (Auer, et al., 2009b) offers a Knowledge Base with RDF descriptions of more than 350 million spatial features from the OpenStreetMap database linked to DBPedia.
- Location based solution, e.g., the DBpedia Mobile (Becker & Bizer, 2008), a location-aware client for mobile devices.
- RDF repositories with some spatial request support, e.g., Triplify (Auer, et al., 2009) geographic Web platforms offering semantic geocoding, e.g., Yahoo GeoPlanet and GeoNames.

Geospatial Web

- Any Geospatial Web framework which publish information about geographic features uses unique identifiers (within this framework at least) and might be seen as a source of geoidentifiers.
- One of the earlier proposals from the OGC community to apply common geographic identifiers for linking purposes is a framework based on Geolinked Data Access Service and Geolinking Service. However the geoidentifiers are used only as syntactic link.
- EuroGeoNames project - Europe level gazetteer which enables integrated view across distributed services. However, these identifiers still remain unique only in this distributed gazetteer.

Geo-concept modelling



Description of a general understanding of a concept. Spatial reference usually refer to existence in the real world in tme *t*.

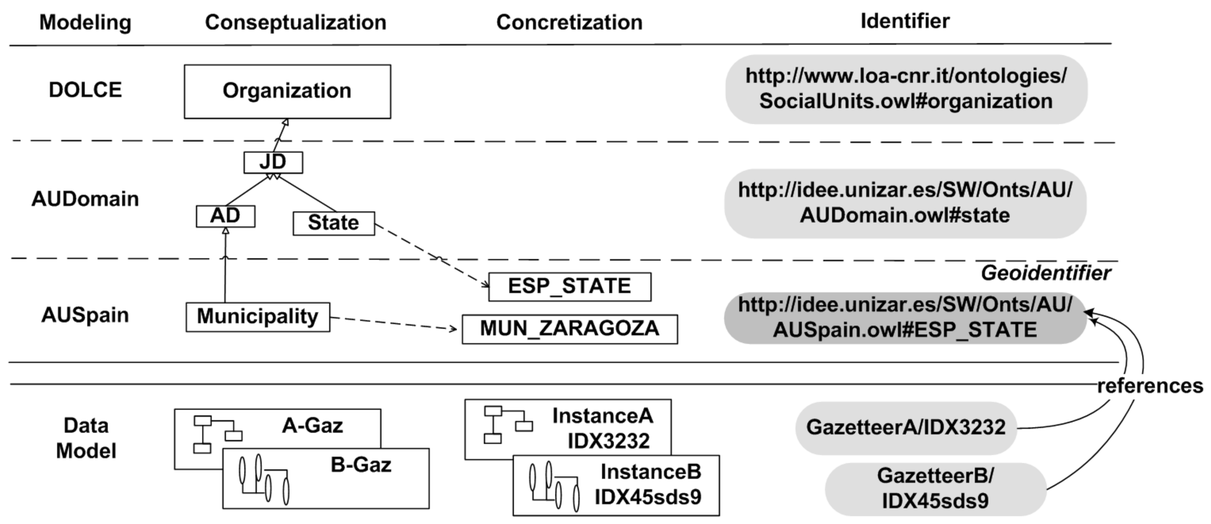
Definition of spatial realization of a geo-concept linked to a concrete domain, the definition of its spatial realization is quite dificult and comes as a fuzzy definition (e.g., a river).

Some footprints might not have computational representation.

Spatial object is a computational representation of the Individual footprint. Its type or serialization depends on the application requirments, e.g., it permits localise on a map the individual (Point) or vizualize it with necessary precision (Polygon). Spatial object enables also reasoning on spatial relations it involves.

Linking Instances: conceptualization

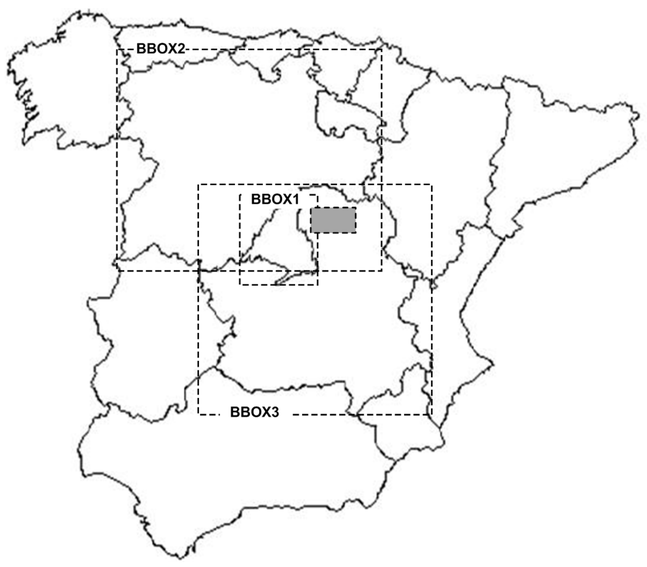
An administrative unit is presented in various datasets. It might be interesting to be able to maintaine a link between its instances (reach models, itegration scenarios)



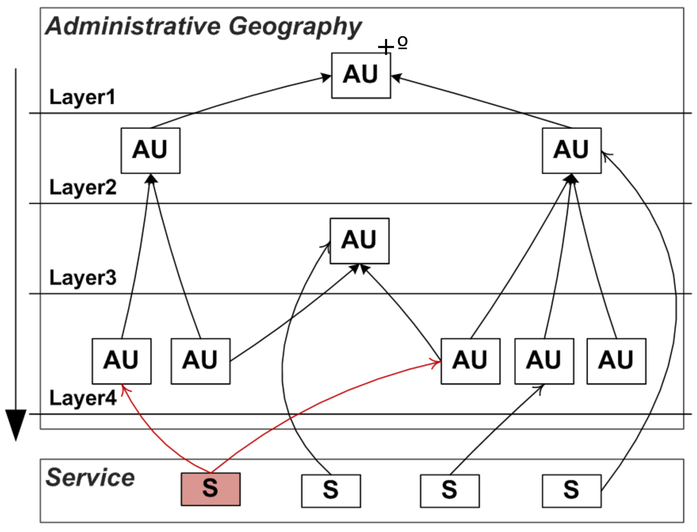
Application Scenario

In INSPIRE, service discovery requests allow restricting the geographic extent of searched datasets and services to a required MMB. Frequently, the geographic extent of published data and service corresponds with the coverage of an individual from a geographic ontology (e.g., Europe from a geographic region ontology, Europe Union from a political organization ontology). Therefore, using MMB to describe available resources usually introduces false positives in the collection of results.

Spain Example



Service coverage estimation alrotithm



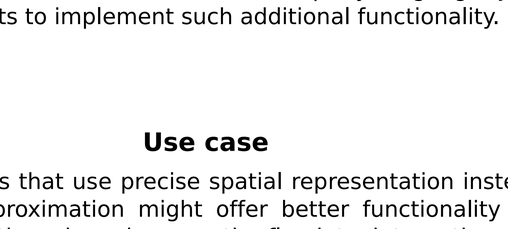
Implementation

```
llayer = Layer[0..N]
serv = Service();
n = 0;
auRes = null;
while( n<N && auRes==null ) {
 v = coverAU( serv.bbox(), llayer[n] ); //SPARQL request (1)
 for(x: v) {
  n = N;
  if( noDataOutside( serv, x.bond-1000() ) ) //WFS request
   auRes = x;
 }
 n++;
}

(1)SELECT ?x WHERE {
?x rdf:type $AU;  agont:bond-1000 ?g.
FILTER(sf:INTERACT(?g, $BBOX))}
```

Service Catalog Extension

The services catalog deployed in SDI of Spain (Nogueras-Iso, et.al., 2009) has been semanticaly enabled



Servcie semantic search template

($BBOX is the MMB literal, eg., "-1.1724,41.4527,-0.6478,41.9324")

```
PREFIX dc: <http://purl.org/dc/elements/1.1/>
(..)

SELECT ?s
WHERE {
?s rdf:type svont:service;
dc:coverage ?x.
?x rdf:type agont:au;
agont:bond-1000 ?g.
FILTER(sf:INTERACT(?g, $BBOX)) }
(..)
SELECT ?s
WHERE {
?s rdf:type svont:service;
dc:coverage agont:Non;
svont:bbox ?g.
FILTER(sf:INTERACT(?g, $BBOX)) }
```

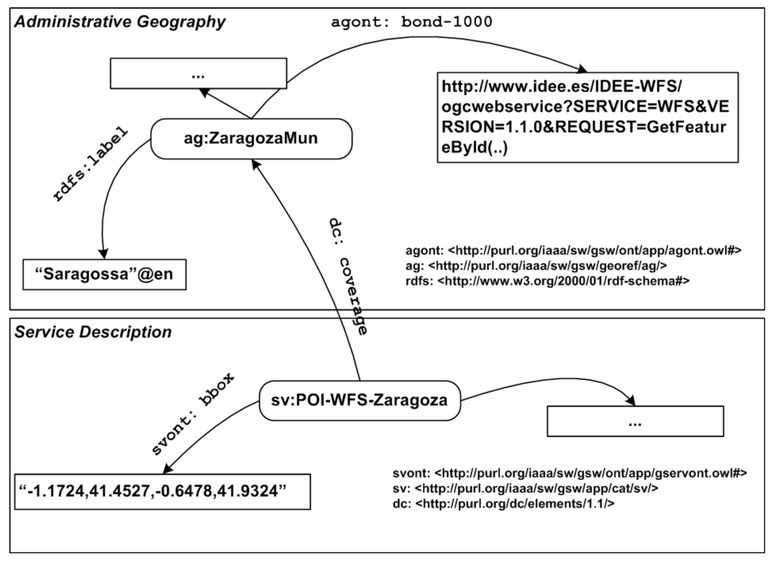
Implementation Issues

The Knowledge Centre component has required implementation of the spatial functions, such as intersect, or within, known form spatial data bases. Therefore, the Jena framework has been chosen to deploy RDF datasets as its proprietary extension to SPARQL RDF query language (Jena ARQ) permits to implement such additional functionality.

Data

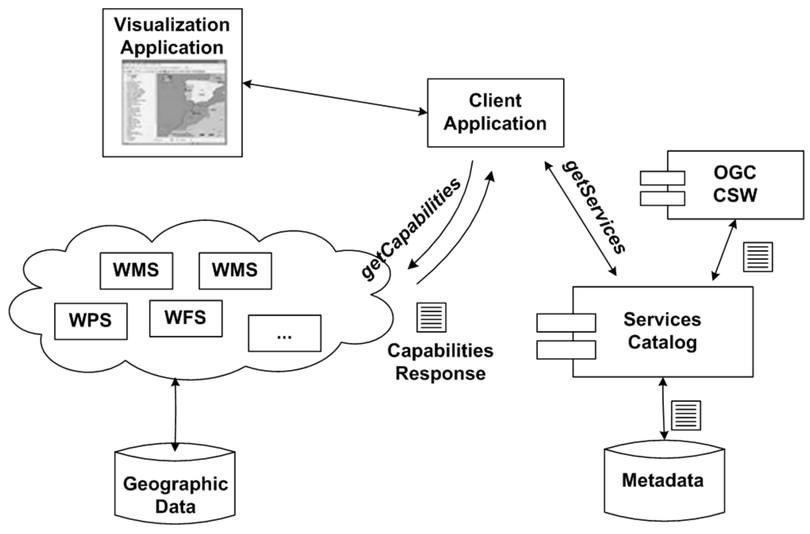
```
@prefix au: <http://purl.org/iaaa/sw/gsw/ont/au-spain.owl#>.
@prefix agont: <http://purl.org/iaaa/sw/gsw/ont/app/agont.owl#>.
@prefix ag: <http://purl.org/iaaa/sw/gsw/georef/ag/>.
@prefix rdf: <http://www.w3.org/1999/02/22-rdf-syntax-ns#>.
@prefix rdfs: <http://www.w3.org/2000/01/rdf-schema#>.
@prefix skos: <http://www.w3.org/2009/08/skos-reference/skos.rdf#>.
ag:ZaragozaMun rdf:type au:Municipality;
rdfs:label "Zaragoza"@es,"Zaragoza"@en;
au:part-of ag:Spain, ag:AragonComunidad;
au:member-of ag:ZragozaComarca;
skos:relatedMatch <http://www.idee.es/IDEE-WFS/ogcwebservice?
SERVICE=WFS&VERSION=1.1.0&REQUEST=GetFeatureById(..)>;
(. . .)
agont:bond-100 <http://www.idee.es/IDEE-WFS/ogcwebservice?
SERVICE=WFS&VERSION=1.1.0&REQUEST=GetFeatureById(...)>.
```

Link between the service description and the administrative geography.



Use case

The catalogs that use precise spatial representation instead of MBB approximation might offer better functionality for the applications based on on-the-fly data integration. An example might be an application which allows displaying geographic information from different OGC services found in the services catalog. For improving the user experience, the list of selectable layers should depend on current displayed area.



Conclusions

Applying best practices from the Semantic Web might be useful for the Geospatial Web. An administrative geography published in accordance with Linked Data principles might be useful for data integration as it permits referencing the geographic concept to the corresponding instances from other sources. Such ontology might be used as source of geoidentifiers in geospatial solutions and its main advantage lies in using more precise spatial representation and spatial reasoning on semantic level.

Additionally, the usage of geoidentifiers along with minimum bounding boxes to represent the service geographic extents might improve the recall of OGC services catalog. For instance, we have demonstrated that this improvement has enabled the development of web-based applications that facilitate on-the-fly data integration. The principal advantage of using Linked Data technology in geospatial solutions is the possibility of explicit identification of features and abstraction of their spatial definition from footprint and computational representation. The different spatial representation might be accessible via linked instances and chosen according to the application requirements.

References

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Nogueras-Iso, J., Barrera, J., Rodrígez, A.F., Recio, R., Laborda, C. and Zaragaza-Soria, F.J. (2009) Development and deployment of a services catalog in compliance with the INSPIRE metadata implementing rules, SDI Convergence: Research, Emerging Trends, and Critical Assessment. The Netherlands Geodetic Commission (NGC), 2009, pp. 21—34.