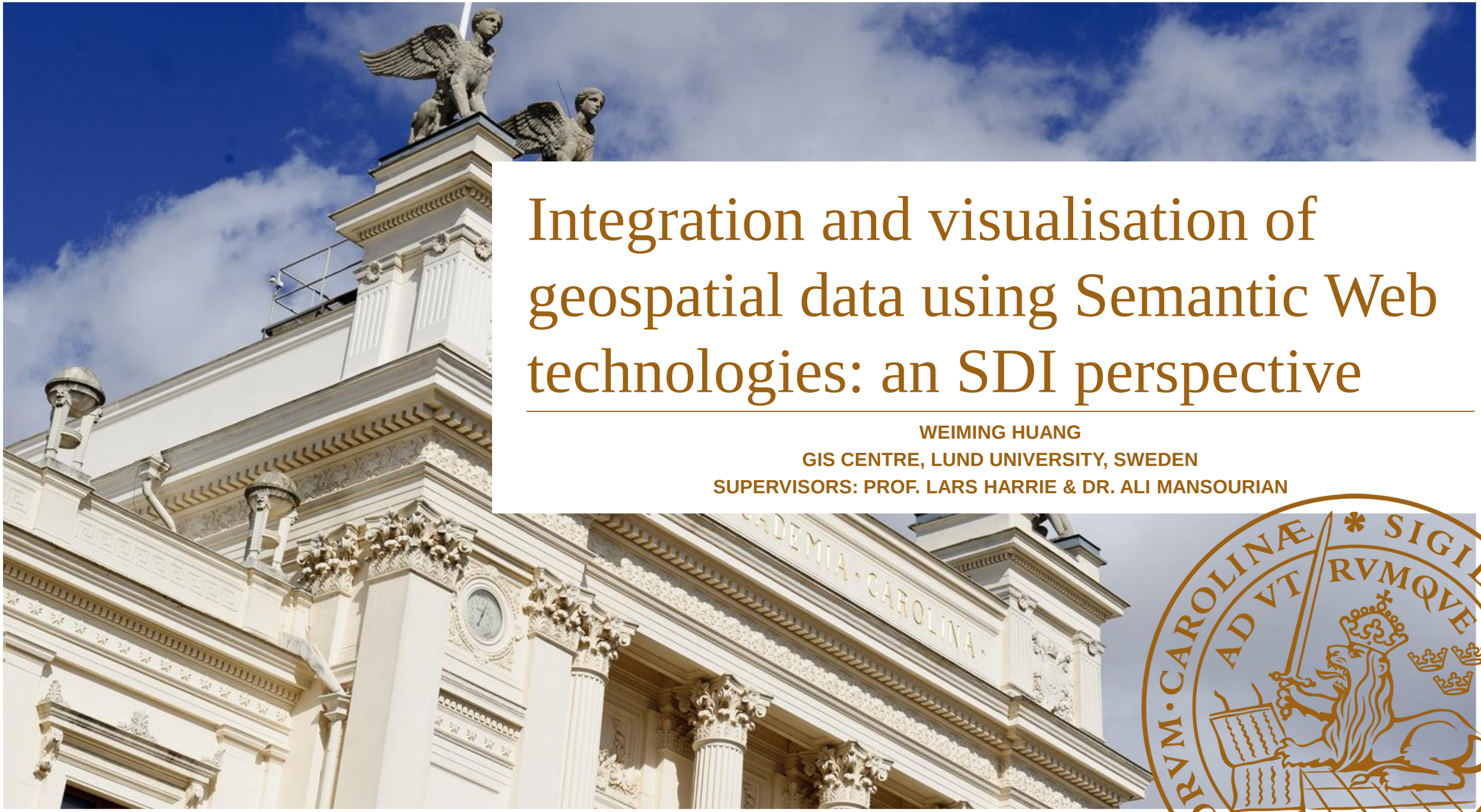

Integration and visualisation of geospatial data using Semantic Web technologies: an SDI perspective

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SUPERVISORS: PROF. LARS HARRIE & DR. ALI MANSOURIAN

Geospatial data are increasingly available

- Increasing availability of geospatial data is coming to us:
  - Efforts of improving the availability of geospatial information from authorities;
  - Increasing amount and sorts of volunteered geographic information (VGI).

- This leads to more analyses and visualisation of data from several different sources. To enable this, we need homogenous data as well as proper integration methods.

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Semantic Web technologies and Linked Data

- Semantic Web (Web 3.0) - a way of linking data between systems or entities that allows for rich, self-describing interrelations of data available across the globe on the web.
- The term was coined by Tim Berners-Lee for a web of data. Some proponents argue that applications in industry, biology and human sciences research have already proven the validity of the original concept.
- Linked Data paradigm is a method of publishing structured data so that it can be interlinked and become more useful through semantic queries.

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Semantic Web technologies and Linked Data

- The application of Semantic Web technologies and Linked Data has developed considerably in the last decade in geospatial domain as they address several challenges of e.g. data integration, reuse, semantic interoperation and knowledge formalisation.
- NMAs are investigating the potential of linked data and some of them have started releasing authoritative geodata as linked open data.

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INSPIRE Linked Data

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European Commission

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Linking INSPIRE data: draft guidelines and pilots

Details

The Joint Research Centre (JRC) of the European Commission is investigating how the RDF encoding of spatial data can facilitate cross-sector interoperability and help reuse of the investments of INSPIRE in other data infrastructures, including Linked Data and Open Data Portals.

The e-Government and open data communities in Europe are increasingly looking at "Linked Data" approaches. In particular, the Resource Description Framework (RDF), a developer-friendly W3C specification for building the Semantic Web, can help data owners and data users to publish and combine different 'self-describing' datasets. Given its potential to help link geospatial data with other data sources, the JRC is developing RDF vocabularies for the INSPIRE spatial data themes, which will allow interested data providers to also use RDF (in addition to the default GML encoding) to share and link geospatial data in Europe

To ensure that these vocabularies follow a common approach, a proposal for common encoding guidelines has been developed. Formally, these guidelines follow the legal requirements in INSPIRE for specifying additional representations by showing how the spatial object types defined in the INSPIRE conceptual data models should be represented in RDF. Moreover, they act as a signpost for everyone who wants to use RDF to represent or consume INSPIRE data, especially those familiar with Semantic Web technologies.

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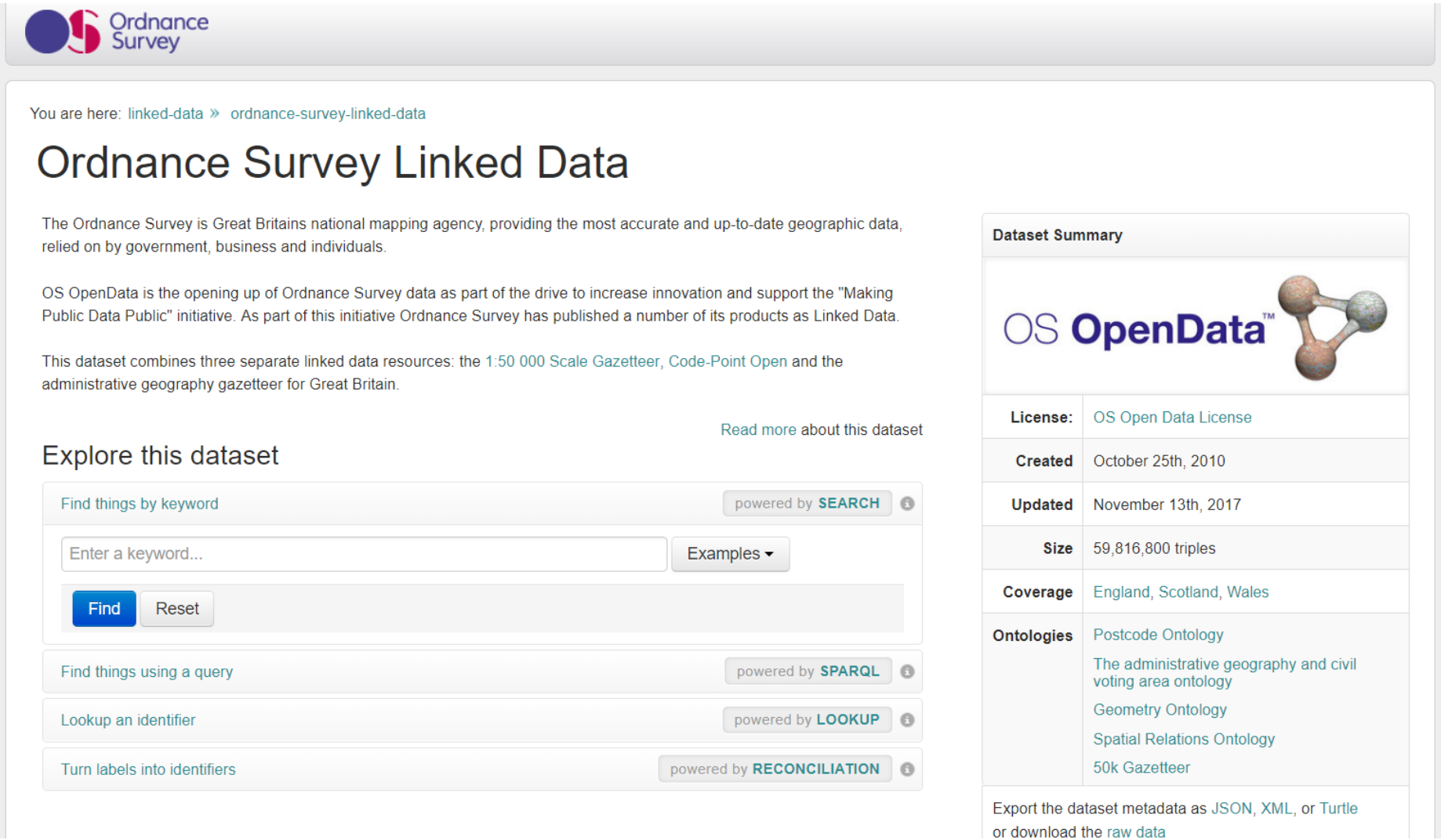
Ordnance Survey Linked Data



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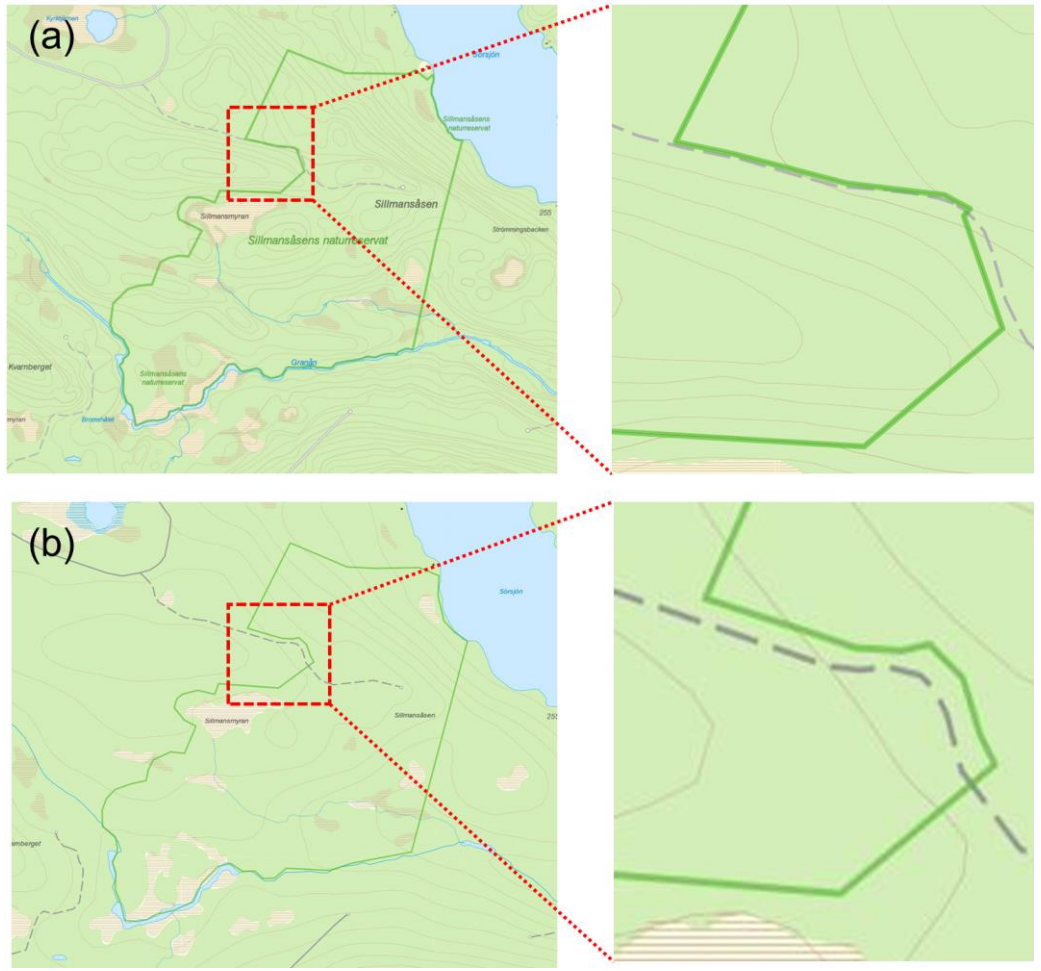
Study 1 (finished)

Synchronising geometric representations for map mashups using relative positioning and Linked Data

Current map mashups

- Created by simply overlaying thematic layer on a base map
- The levels of detail between thematic layer and base map are barely synchronised and this raises geometric inconsistencies and sometimes confusing for web map users.



Sillmansåsen(© Lantmäteriet, Dnr: I2014/00579)

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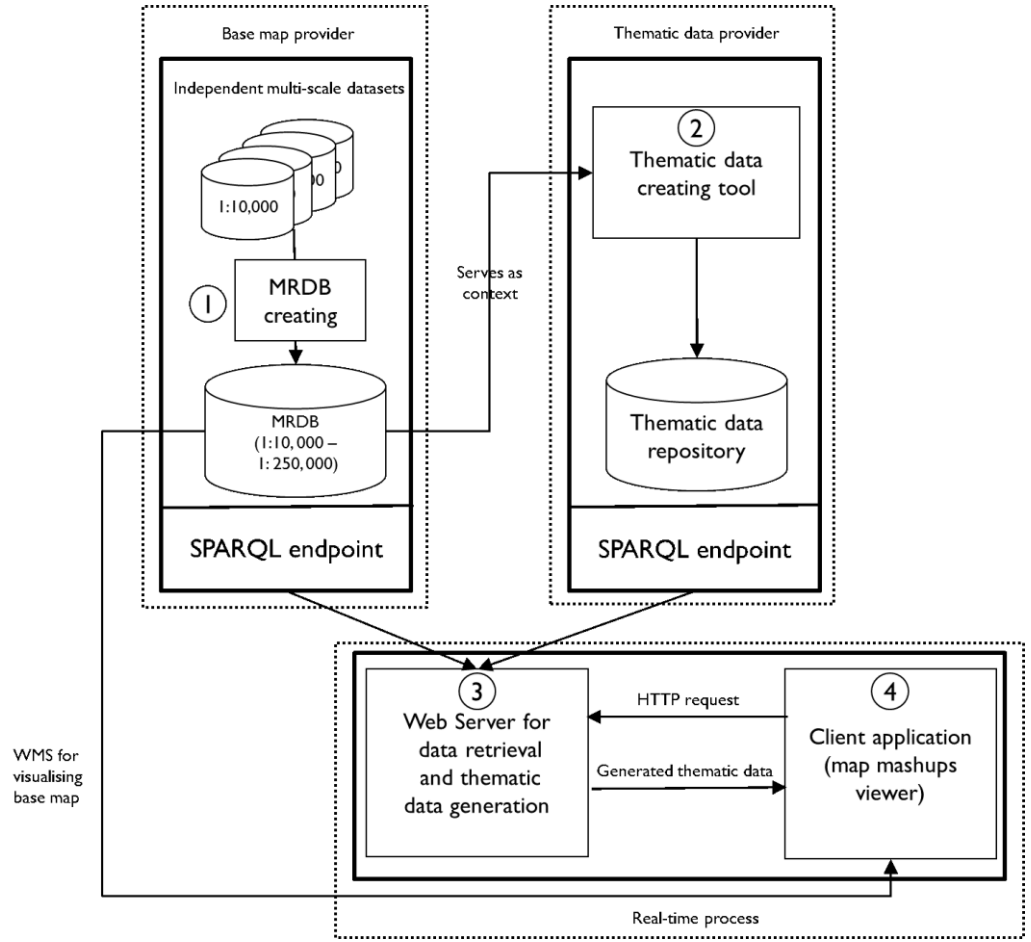
Linked Data-based relative positioning

- Relative positioning utilises features in the base map



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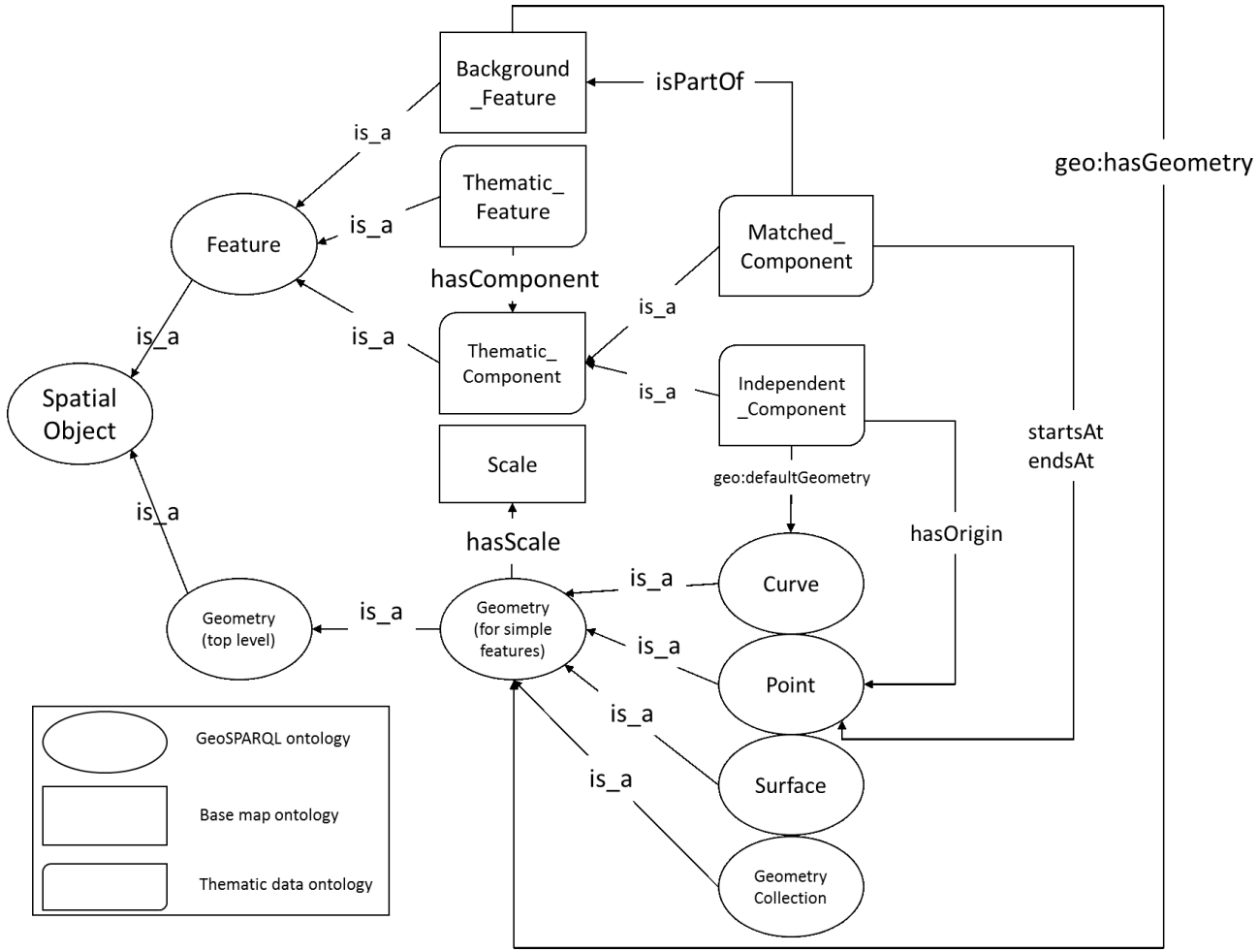
Ontologies



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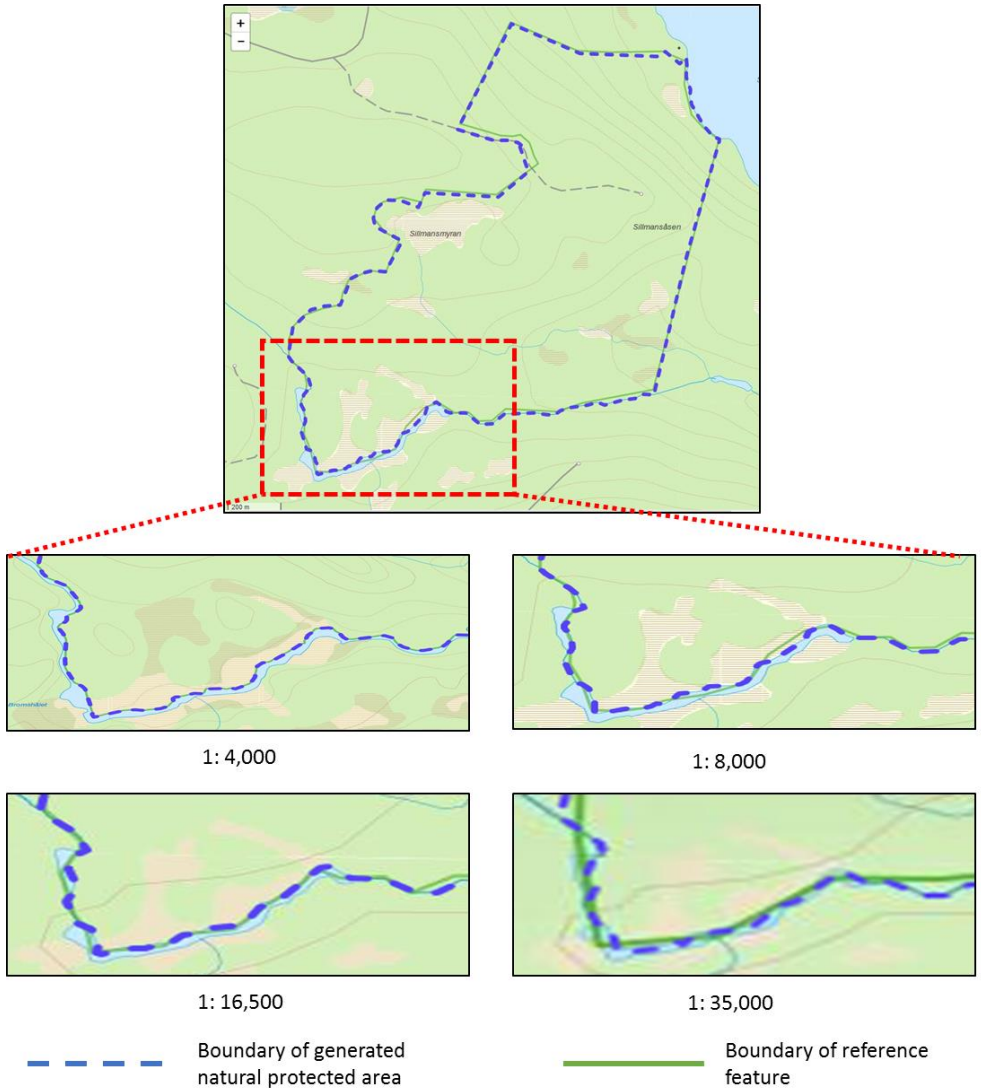
Outcome



Advantages:

- Automatic update (persistent URIs are a key)
- Self-adapting in other contexts (interlinked RDF geodata)
- Reduce the time of real-time generalization
- Unlocked potential for spatial analysis
- In SDI, if one provides geospatial data in Linked Data, then others could link their data to the reference data

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Journal
International Journal of Geographical Information Science ›
Volume 32, 2018 - Issue 6

Research Article

Synchronising geometric representations for map mashups using relative positioning and Linked Data

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Pages 1117-1137 | Received 19 Jul 2017, Accepted 13 Feb 2018, Published online: 01 Mar 2018

 https://doi.org/10.1080/13658816.2018.1441416

ABSTRACT

Map mashups, as a common way of presenting geospatial information on the Web, are generally created by spatially overlaying thematic information on top of various base maps. This simple overlay approach often raises geometric deficiencies due to geometric uncertainties in the data. This issue is particularly apparent in a multi-scale context because the thematic data seldom have synchronised level of detail with the base map. In this study, we propose, develop, implement and evaluate a relative positioning approach based on shared geometries and relative coordinates to synchronise geometric representations for map mashups through several scales. To realise the relative positioning between datasets, we adopt a Linked Data–based technical framework in which the data are organised according to ontologies that are designed based on the GeoSPARQL vocabulary. A prototype system is developed to demonstrate the feasibility and usability of the relative positioning approach. The results show that the approach synchronises and integrates the geometries of thematic data and the base map effectively, and the thematic data are automatically tailored for multi-scale visualisation. The proposed framework can be used as a new way of modelling geospatial data on the Web, with merits in terms of both data visualisation and querying.

KEYWORDS: Map mashups, geometry synchronisation, multiple representation, relative positioning, Linked Data

Study 2 (ongoing)

Towards knowledge-based geovisualisation
using Semantic Web technologies:
a knowledge representation approach coupling ontologies and rules

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Geovisualisation is knowledge-intensive

Geovisualisation:

- A fundamental and core application of GIS
- Knowledge-intensive for both providers and users:
  - For providers to derive sensemaking and cartographically satisfactory applications
  - For users to make sense of the visualised data
- Current solutions, e.g. SLD, lack semantics.

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Knowledge-based geovisualisation

Geovisualisation involves knowledge in a number of aspects:

- Cartographic scale
- Portrayal
- Geometry source (can be distributed in the environment of Linked Data)

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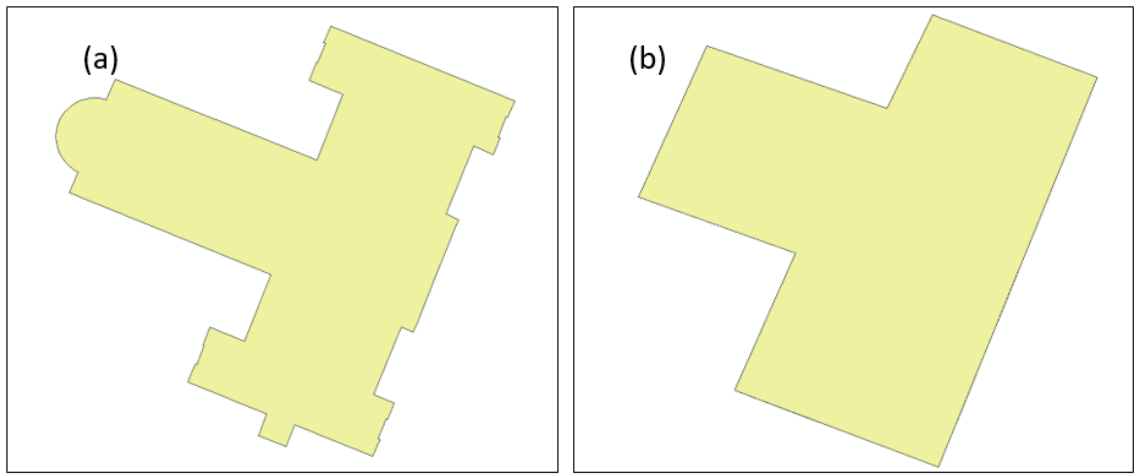
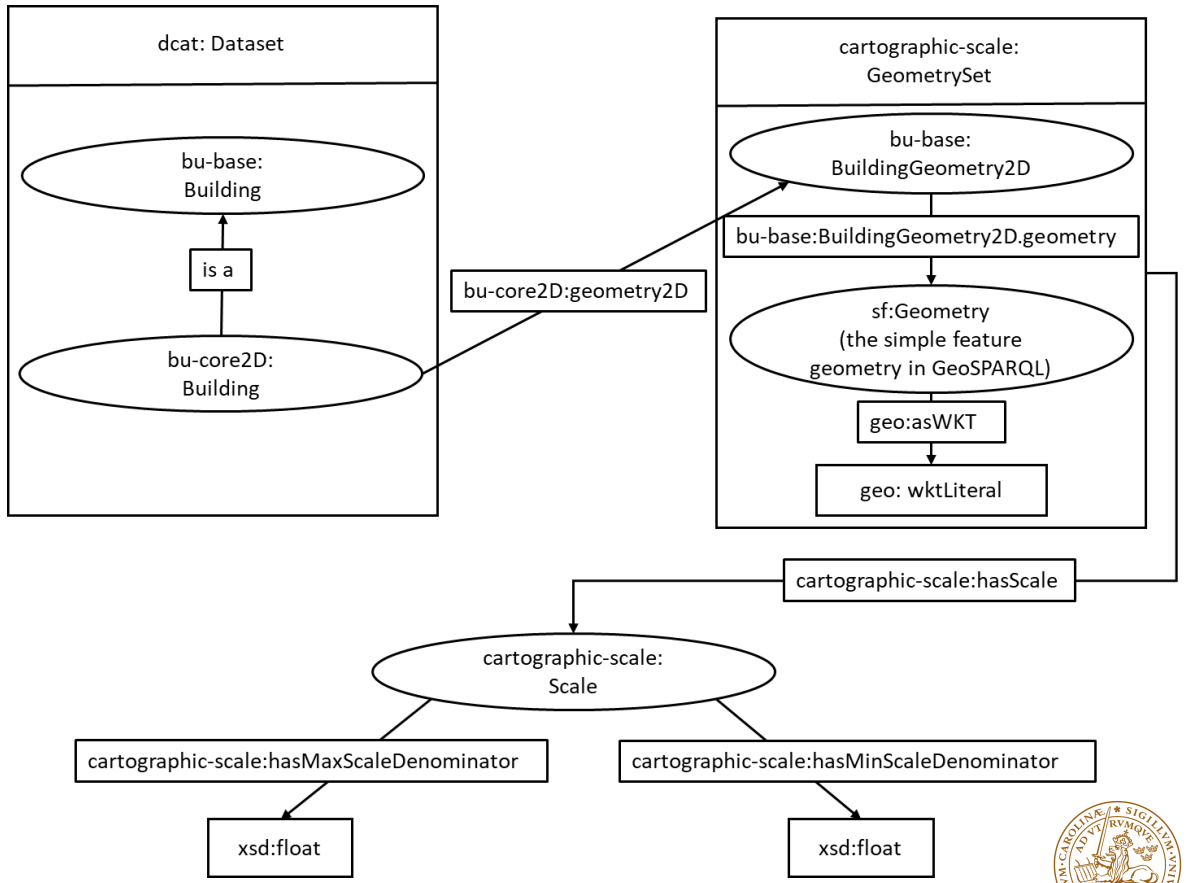
Cartographic scale

- Data are modelled in INSPIRE draft 2D building vocabularies
- Metadata are in GeoDCAT-AP
- The scale is defined at *GeometrySet* level





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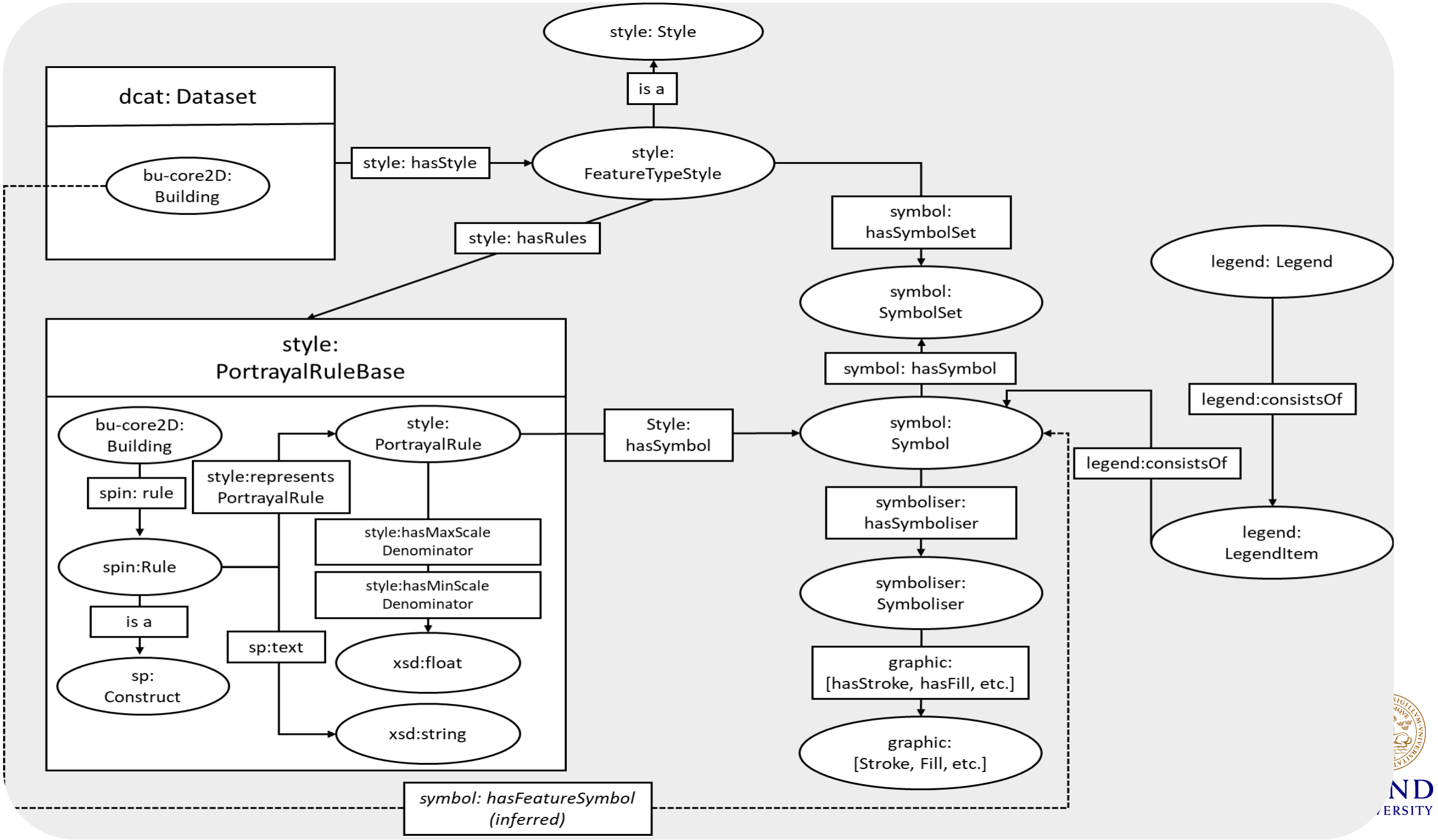
style: Style
is a
dcat: Dataset
bu-core2D: Building
style: hasStyle
style: FeatureTypeStyle
style: hasRules
symbol: hasSymbolSet
symbol: SymbolSet
symbol: hasSymbol
legend: Legend
legend:consistsOf
style: PortrayalRuleBase
bu-core2D: Building
spin: rule
spin:Rule
is a
sp: Construct
style: PortrayalRule
style:represents PortrayalRule
style:hasMaxScale Denominator
style:hasMinScale Denominator
sp:text
xsd:float
xsd:string
Style: hasSymbol
symbol: Symbol
legend:consistsOf
symboliser: hasSymboliser
symboliser: Symboliser
graphic: [hasStroke, hasFill, etc.]
graphic: [Stroke, Fill, etc.]
legend: LegendItem
symbol: hasFeatureSymbol (inferred)

Portrayal rule example

```
@[prefix definitions]
bu-core2D:Building a owl:Class;
                    spin:rule[
                     a sp:Construct;
                     style:representsPortrayalRule portrayal:portrayal_rule_0;
                     sp:text"""
                         CONSTRUCT {?this symbol:hasFeatureSymbol portrayal:symbol_0}
                         WHERE{
                         ?this bu-base: AbstractConstruction.dateOfConstruction/
                         bu_base:DateOfEvent.end> ?built_up_time.
                         BIND(year(now())-year(xsd:dateTime(?built_up_time)) as ?age)
                         FILTER(?age>300)
                         graph <URI of the client context named graph>{
                         ?client_scale a scale:ClientVisualisationScale;
                         scale:hasScaleValue ?rendering_scale.
                         FILTER(?rendering_scale<=10000)}
                         }
"""
     ].
```

```
[prefix definitions]
SELECT ?feature ?symbol
FROM <URI of the geospatial dataset (named graph)>
FROM <URI of the client context named graph>
WHERE
{
    ?feature a bu-core2D:Building;
        symbol:hasFeatureSymbol ?symbol.
}
```

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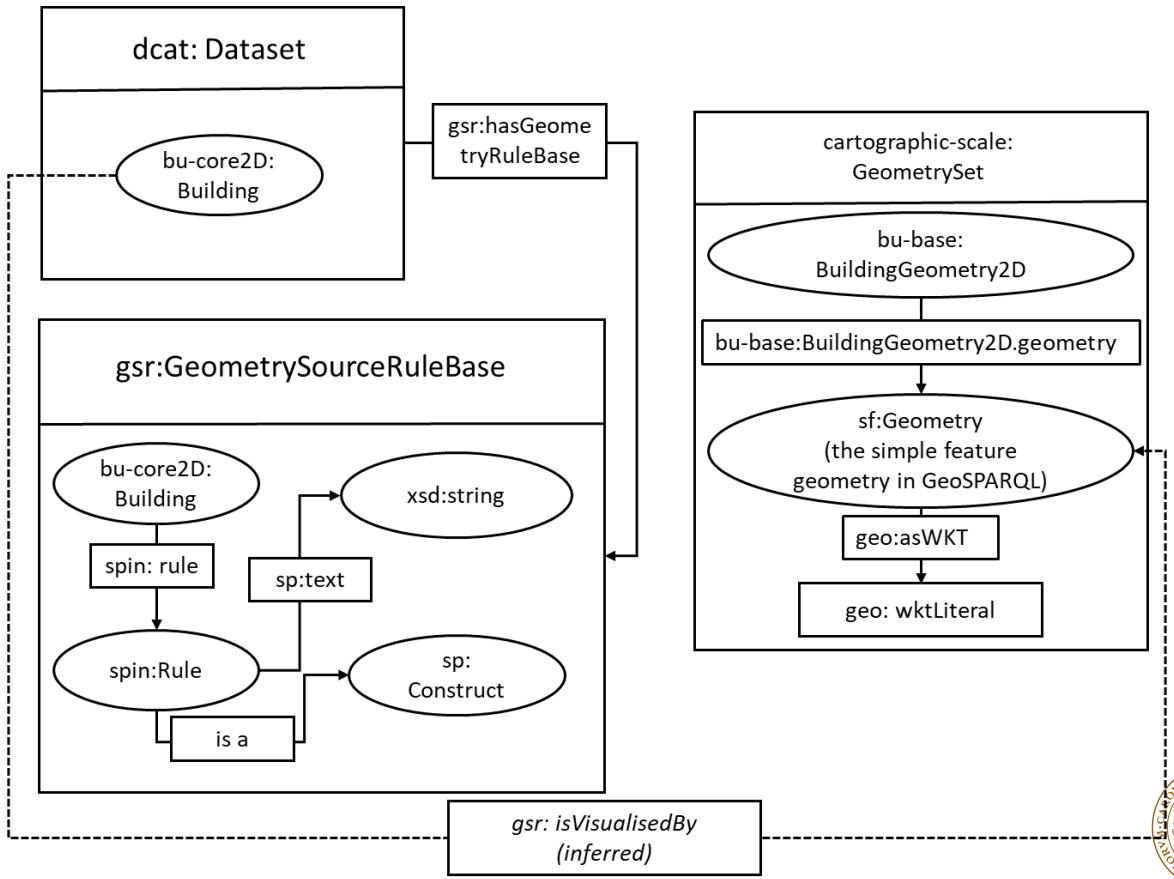
Geometry source(s)

- Linked Data brings up the opportunity of *integrated visualisation*
- For different applications and under different conditions, different geometry sources can be used



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Case study – Swedish heritage building map

- Study area: centre Stockholm
- Data sources:
  - Heritage building data (points) from Swedish national heritage board
  - NMA data (multi-scale polygons)
- Semi-automatic Interlinking (overlap with manual check)
- Portrayal rules are based on ages
- Use detailed geometry in large scales, and coarse geometry in small scales (has not been fully implemented)

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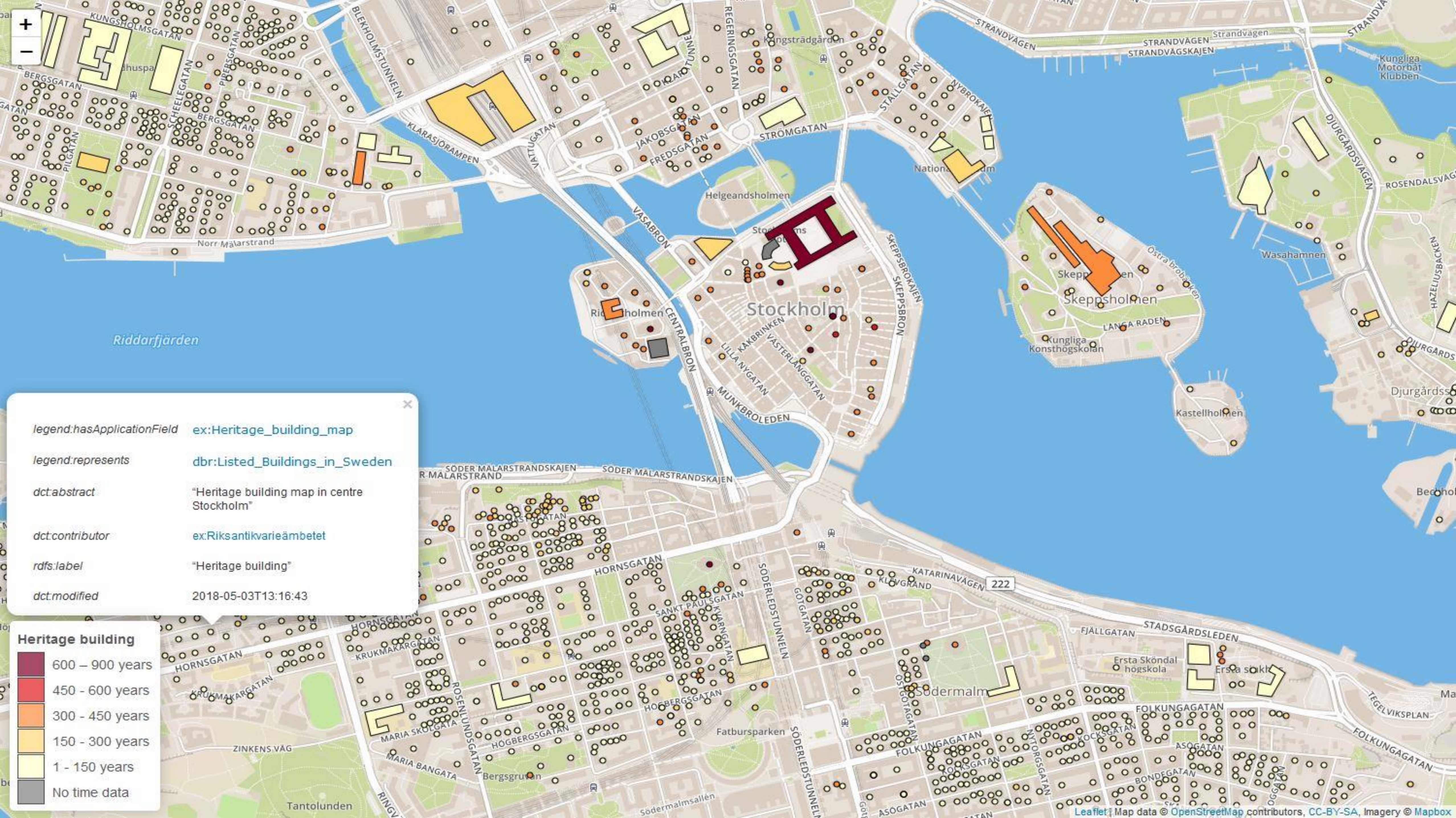

legend:hasApplicationField
ex:Heritage_building_map
legend:represents
dbr:Listed_Buildings_in_Sweden
dct:abstract
“Heritage building map in centre Stockholm”
dct:contributor
ex:Riksantikvarieämbetet
rdfs:label
“Heritage building”
dct:modified
2018-05-03T13:16:43
Heritage building
600 – 900 years
450 - 600 years
300 - 450 years
150 - 300 years
1 - 150 years
No time data
Leaflet | Map data © OpenStreetMap contributors, CC-BY-SA, Imagery © Mapbox
Stockholm
Riddarfjärden
Helgeandsholmen
Skeppsholmen
Kastellholmen
Kungliga Konsthögskolan
Södermalm
Fatburparken
Tantolunden
Kungsträdgården
Kungliga Motorbåt Klubben
Wasahamnen
Norr Mälarstrand
KUNGSHOLMSGATAN
BERGSGATAN
SCHEELEGATAN
PILGATAN
KLARASJÖRAMPEN
VATTUGATAN
BLEKHOLMSTUNNELN
REGERINGSGATAN
JAKOBSGATAN
FREDSGATAN
STRÖMGATAN
STALLGATAN
NYBROKAJEN
STRANDVÄGEN
STRANDVÄGSKAJEN
DJURGÅRDSVÄGEN
ROSENDALSVÄGEN
VASABRON
CENTRALBRON
SKEPPSBROKAJEN
SKEPPSBRON
KÅKBRINKEN
VÄSTERLÅNGGATAN
LILLA NYGATAN
MUNKBROLEDEN
SÖDER MÄLARSTRANDSKAJEN
HORNSGATAN
KRUKMAKARGATAN
ROSENLUNDSGATAN
HÖGBERGSGATAN
MARIA SKOLGATA
MARIA BANGATA
ZINKENS VÄG
SANKT PAULSGATAN
SÖDERLEDSTUNNELN
GÖTGATAN
KATARINAVÄGEN
222
FJÄLLGATAN
STADSGÅRDSLEDEN
Ersta Sköndal högskola
FOLKUNGAGATAN
ÖSTGÖTAGATAN
NYTORGSGATAN
ÅSÖGATAN
BONDEGATAN
TEGELVIKSPLAN
Södermalmsallén

Discussion

- This work could potentially form a *web of knowledge for geovisualisation*, which facilitates the transfer, share and reuse of such knowledge.
- Such *web of knowledge for geovisualisation* can be a visualisation enablement layer for the geospatial Linked Data.
- Such knowledge base can be used for outreaching geovisualisation knowledge to other domains where geovisualization is useful.

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Future study

- This would be case study of using Semantic Web for data integration and visualisation/cartographic knowledge outreaching.
- One such ongoing case is the visualisation of cycling level-of-service indexes.

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