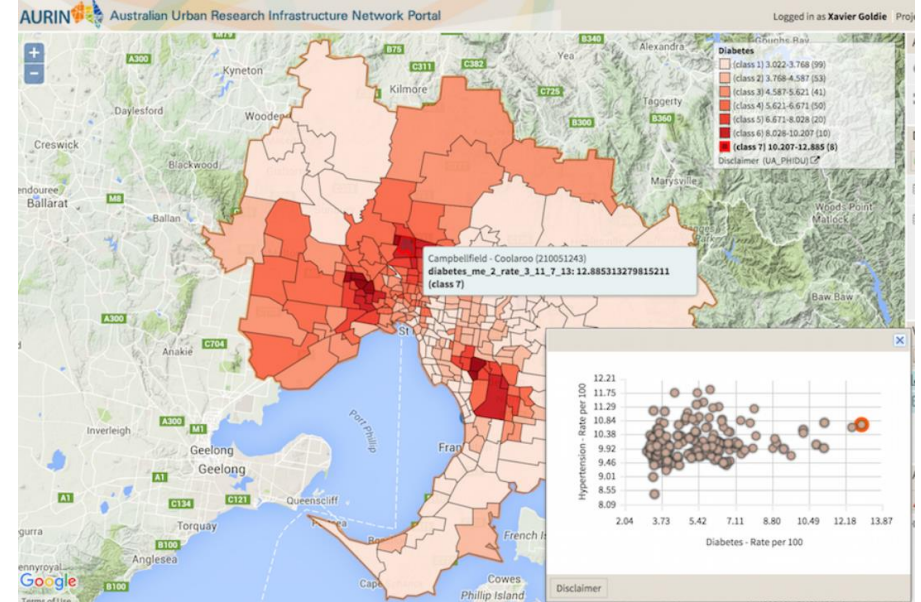


Potentials of linked data for geographic maps and spatial analysis



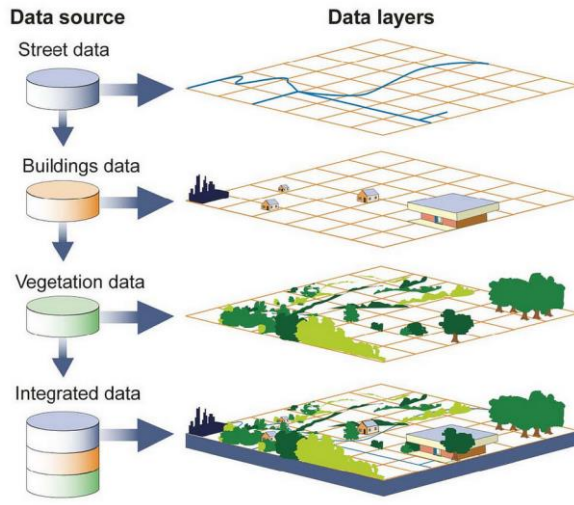
*Simon Scheider**,

*Department of Human Geography and Spatial Planning
Universiteit Utrecht

The data surge and classical map services



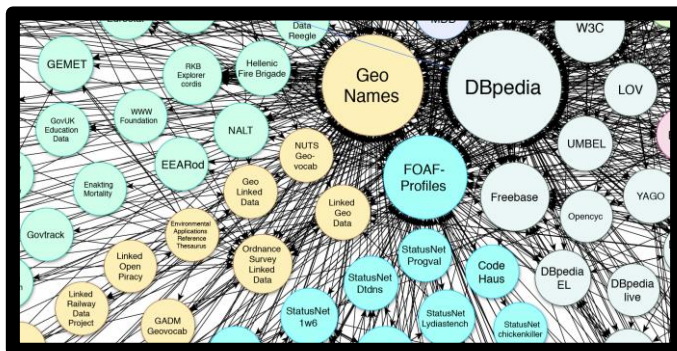
Are classical map services well suited to cope with the surge?



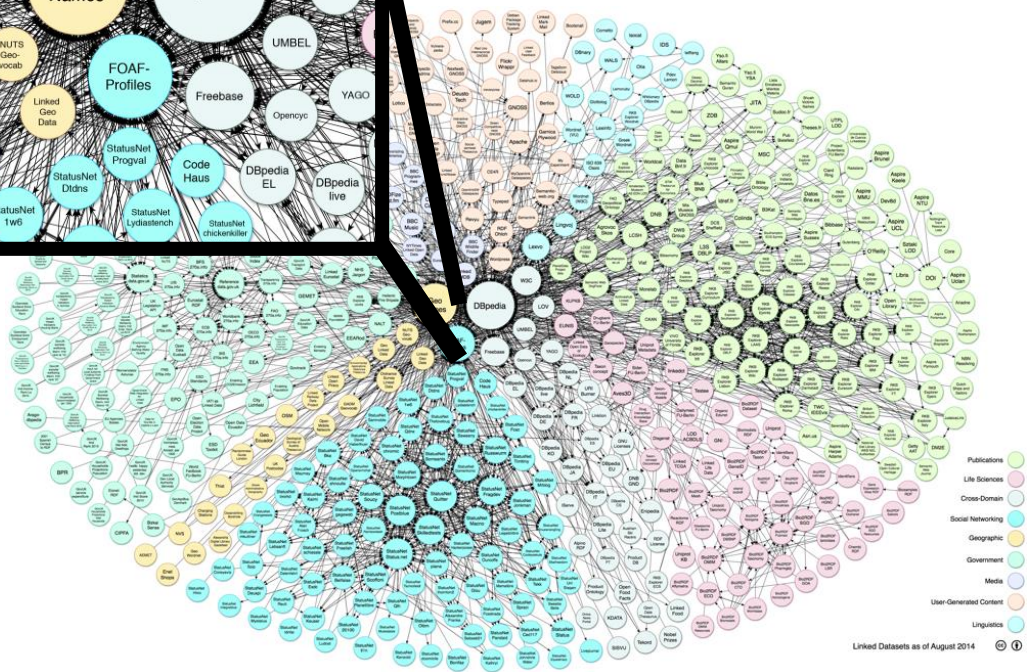
- Data are organized in layers
- Purpose: mapping and analysis, *not sharing*
- Origin and use are homogenous, *not heterogeneous*
- Layers are organized in fixed tables, *cannot be arbitrarily linked*
- Links result from:
 - Space (overlay) and unique names (key)
 - *not via semantic relations*

1) A web view on (geographic) maps

Linked (geospatial) data:
- Everything can be linked to everything else
- Most things are linked to space



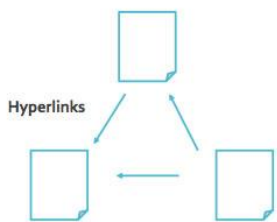
Linked open data (LOD) Cloud 2015



Web of Documents

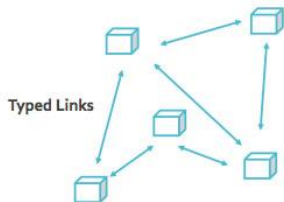


Web of Data



Hyperlinks

"Documents"



Typed Links

"Things"

How can maps?

historians find

Question:

“What was the type of landcover around Hildesheim in the 19th century?”

1) Manual search
(through 20.000 maps?)

2) Text field search:

- **title:**

(“Gaußsche Landesaufnahme”
“Berghe Ducatus”,...)

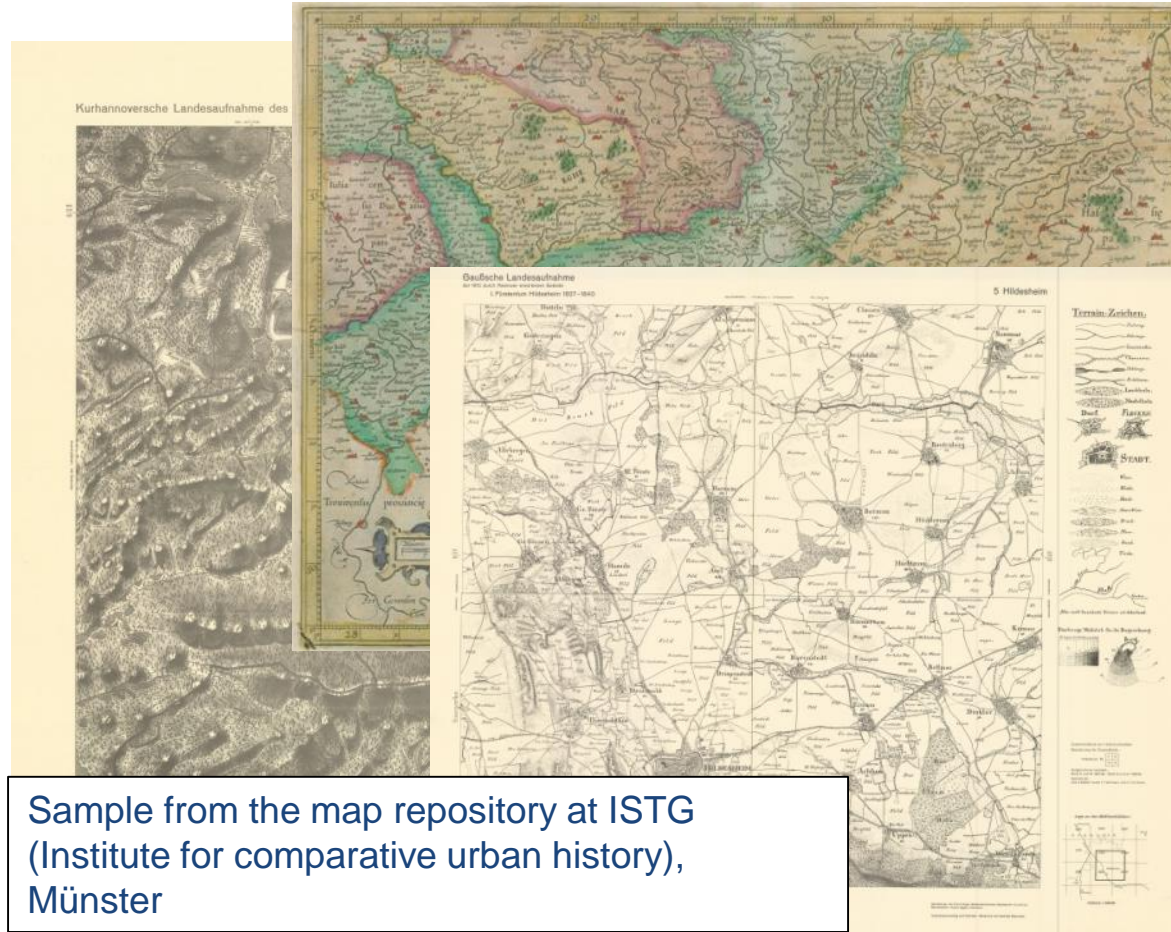
- **author:**

(Gerhard Mercator, ...)

- **year of production**

(1680, 1839, ...)

- **key words:** (“topographic map”,
“Flurkarte”)



Sample from the map repository at ISTG
(Institute for comparative urban history),
Münster

How can (we support) historians (in) find(ing) (answers in) maps?

Technical challenges:

1) Manual search
(through 20.000 maps?)

Not scalable!

2) Text field search:

- **title:**

(“Gaußsche Landesaufnahme”
“Berghe Ducatius”,...)

Language?

There are many languages in maps (Latin, ...)!
Placenames are changing!
Historic maps are distorted and lack CRS!

- **author:**

(Gerhard Mercator, ...)

How to pick the „right“ place/space? („the area around Hildesheim“)

- **year of production**

(1680, 1839, ...)

How to pick the right time? („19th century“)

- **key words:** (“topographic map”, “Flurkarte”)

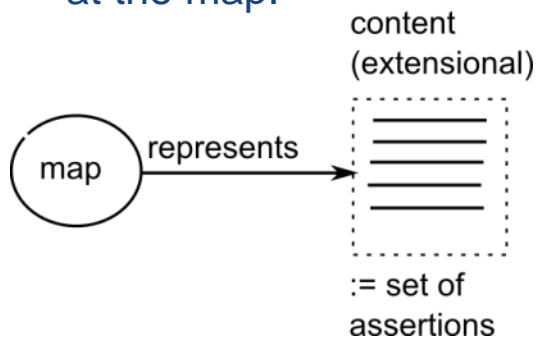
How to pick the „right“ terms? (which correspond to the answer?)

Terms are ambiguous!
There is too much content!
There is nameless content (e.g. „landcover around Hildesheim“)

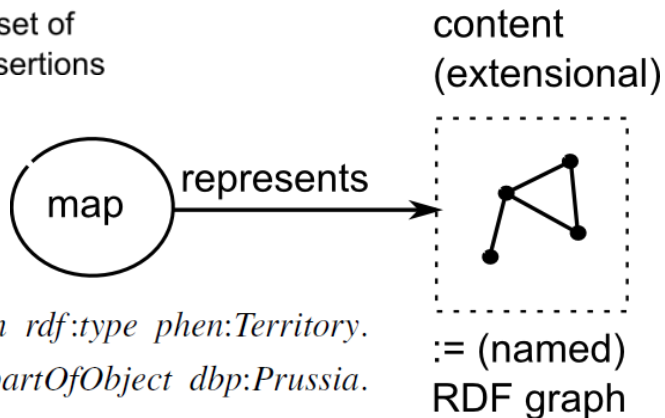
Formally encoding map contents

Scheider et al 2014: *Encoding and Querying Historic Map Content*

Map contents can be treated as **sets of assertions** that can be extracted by looking at the map:

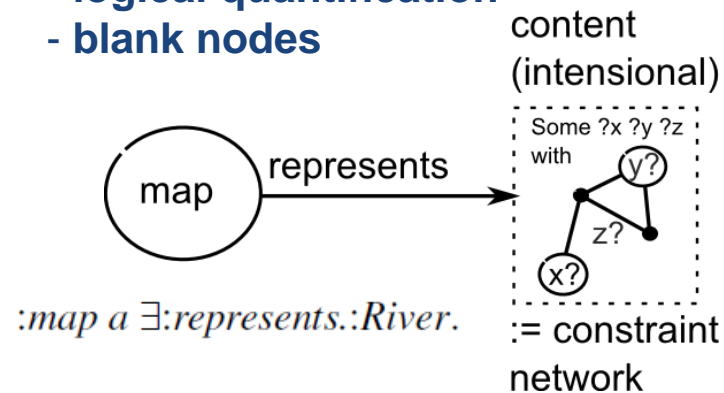


In linked data, this translates into a **named graph**:



dbp:Hinterpommern rdf:type phen:Territory.
dbp:Hinterpommern phen:partOfObject dbp:Prussia.

In the Semantic Web, - **nameless content**
- **wealth of content**
can be addressed by **intensionality**:
- **logical quantification**
- **blank nodes**



:map a ∃:represents.:River.

Encoding maps as linked data

For example, the map about Hildesheim 1840:

Document (graph)
 (describing the map as document)

represents →

Content graph (:hildesheim)
 (describing content assertions)

```
:4354_Hildesheim a maps:Map;
  maps:digitalImageVersion :4354_Hildesheim.jpeg;
  maps:represents :hildesheim;
  maps:hasScale "1:28526.1"^^xsd:string;
  maps:mapSize "62.4 * 55.5 cm"^^xsd:string;
  maps:medium maps:Paper;
  maps:mapsTime "1840"^^xsd:gYear;
  maps:mapsArea _:4354_Hildesheim_geom.
  _:4354_Hildesheim_geom a geo:Geometry
    geo:asWKT "<http://www.opengis.net/def/crs/EPSG/0/4326>
POLYGON((9.874690102339652 52.25156096729222, 9.874324681594004
52.126487663211606, 10.07547489355107 52.1268449901813,
10.073392224324136 52.252405987705664, 9.874690102339652
52.25156096729222))"^^sf:wktLiteral.
```

```
_:someroad a phen:Road ;
  phen:connects _:somevillage ;
  phen:connects dbp:Hildesheim .
_:someroad2 a phen:Footpath .
dbp:Hildesheim a phen:City .
_:somevillage a phen:Village .
_:someblock a phen:Block ;
  phen:partOfObject dbp:Hildesheim .
_:somebuilding a phen:Building .
_:somehill a phen:Elevation .
_:someforest a phen:Wood .
_:somepasture a phen:Pasture .
_:someplace a phen:Non-inhabited .
dbp:Innerste a phen:River ;
  phen:connects dbp:Hildesheim .
...
```

Querying historical map contents

Which maps contain information about ...

the types of landcover around Hildesheim in 1840?

```
SELECT DISTINCT ?map ?class WHERE {
  ?map maps:represents ?g ;
    maps:mapsTime "1840"^^xsd:gYear .
  GRAPH ?g {{dbp:Hildesheim ?p ?o}UNION{?a ?d dbp:Hildesheim}
    ?instance a ?cl .
  }
  ?instance a ?class .
  ?class rdfs:subClassOf phen:Landcover.
}
```

Map	Class
:node18g4sodccx71	historicmapsphen:Village
:node18g4sodccx71	historicmapsphen:Block
:node18g4sodccx71	historicmapsphen:Building
:node18g4sodccx71	historicmapsphen:Elevation
:node18g4sodccx71	historicmapsphen:Wood
:node18g4sodccx71	historicmapsphen:Pasture
:node18g4sodccx71	historicmapsphen:Non-inhabited

Georeferencing and annotating historic maps

1) Georeferencing

Automatic calculation of

- map scale
- map area

The screenshot shows the 'Historic Map Georeferencer' web application. The browser address bar shows the URL: `gfv-siidemo.uni-muenster.de:81/code/georef.html`. The application title is 'Historic Map Georeferencer' and the logo for 'ulb Münster' is visible in the top right.

The interface is divided into several sections:

- Left Panel:** A sidebar with a table of control points under the heading '3 - Map area'. The table has columns for X and Y coordinates.
- Center Panel:** A preview window showing a historic map with several blue location pins. One pin is labeled 'CP_005'.
- Right Panel:** A larger map view showing the georeferenced map overlaid on a modern map of Central Europe. The georeferenced map is outlined in blue and has several blue location pins. One pin is labeled 'CP_005'.

At the bottom of the application, there are navigation tabs: 'Map', 'Metadata', 'Places', 'Links', and 'Description'. The footer includes the 'LODUM LIFE' logo, 'Project in github', and 'WTFPL' license information.

X	Y
6.574922785258167	49.7439
6.318510402112687	51.4449
9.570587809207122	51.7147
9.692281717253486	50.81776
9.177603977409198	50.7722
9.004055419099736	50.6343
9.015182819524728	50.4853
8.941293629144404	50.3322
9.024726723101834	50.1686
9.166846421232151	50.05393
9.189197152485097	49.95875

Georeferencing and annotating historic maps

2) Describe contents

Automatically
suggested content
based on map area,
time window

Reuse of external
information resources
(e.g. the state Berg
at Dbpedia)

Different historians
can contribute to
the same map

The screenshot displays the 'Historic Map Georeferencer' web application. The browser address bar shows 'gfv-slidemo.uni-muenster.de:81/code/georef.html'. The application interface includes a navigation menu on the left with options like '1 - Image', '2 - Control Points', '3 - Map area', '4 - Ruier', and '5 - Results'. The main area features a historic map of the 'BERGHE Ducatus MARCK CO. mitatus et COLONIENSIS Diocesis' with a blue georeferencing overlay. A 'Suggested tags' panel on the right lists relevant entities such as 'Palatinate-Zweibrücken', 'Prince-Bishopric of Paderborn', and 'Berg (state)', with 'Berg (state)' selected. A tooltip for 'Berg (state)' provides a brief historical description. The bottom of the page features the 'LODUM LIFE' logo, 'Project in github', and a navigation bar with 'Map', 'Metadata', 'Places', 'Links', and 'Description' buttons.

Facetted search with maps (Gfacet)

Gfacet:
Faceted
browser
with Google
map
(Heim, Ertl,
Ziegler 2010)

Songs (6/10)	
Titel	Status
The Greatest Man That Ever Lived (Variations on a Shaker Hymn)	valid
Troublemaker	valid
My Name Is Jonas	valid
Tonight, Tonight	valid
No One Else	valid
Mellon Collie And The Infinite Sadness	valid
Shiver	invalid
Life In Technicolor	invalid
Cemeteries Of London	invalid

Albums (3/5)	
Titel	Status
Mellon Collie and the Infinite Sadness	valid
Weezer (Red Album)	valid
Weezer (Blue Album)	valid
Parachutes	invalid
Viva La Vida	invalid

Bands (2/3)	
Titel	Status
Weezer	valid
Smashing Pumpkins	valid
Coldplay	invalid



Cities (2/3)	
Titel	Status
Los Angeles	valid
Chicago	valid
London	invalid

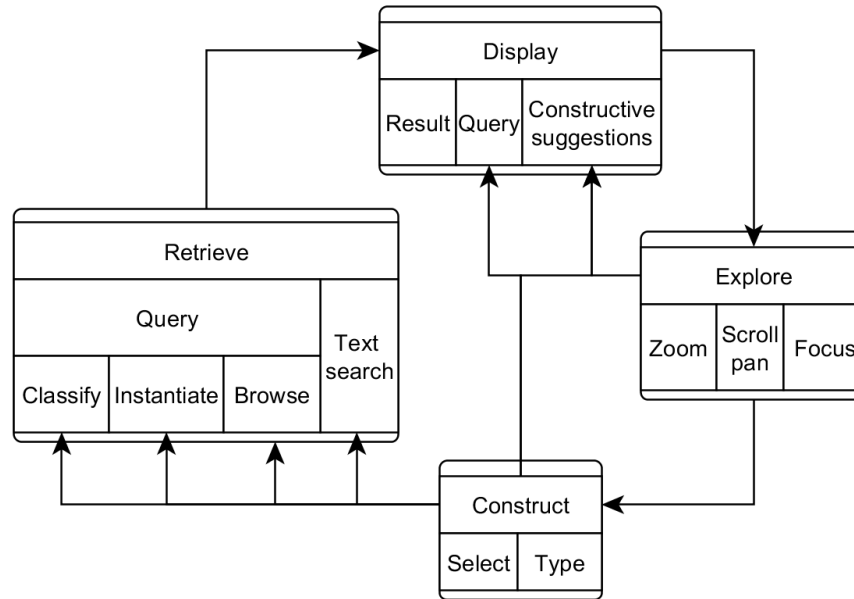
partOf

writtenBy

isFrom

isLocatedAt

Spatio-temporal explorative query of linked data



Scheider et al 2016: [Exploratory querying of SPARQL endpoints in space and time](#)

Spatio-temporal explorative query of linked data (SPEX)

SPEX Spatio-temporal content explorer Endpoint: <http://giv-lodum.uni-muenster.de:8081/parliament>

```
graph TD; phen:Village ---|maps:mapsPhenomenon| maps:Map; maps:Map ---|maps:hasScale| var1;
```

Map showing a bounding box around the Reichenberg area, including locations like Höchberg, Gerbrunn, Reichenberg, and Eibelstadt.

1 am looking for: (2 classes available)

Things of a kind Particular things

Specify relationship to other things (7)

Filter results by map window
Remove Temporal Filter

Clear Map Clear Timeline

	<input type="text" value="Gefecht bey Reichenbe"/>	<input type="text" value="Übersicht"/>	
1756	1757	1758	1759

Results (5): [download results as JSON](#)

?maps:Map	?var1	?phen:Village
Übersichts Karte von Hannibal's Zug über die Alpen	1:14130528.3	Mouliers
Übersichts Karte von Hannibal's Zug über die Alpen	1:14130528.3	Gap
Carte Particuliere D'Amstelland	1:1157907.8	noName
Gefecht bey Reichenberg in Böhmen	1:834759.1	Reichenberg

Query:

```
SELECT
DISTINCT
*
WHERE {
  ?var0 a maps:Map.
  ?var0 maps:hasScale ?var1.
  ?var0 maps:mapsPhenomenon ?var2.
  ?var2 a phen:Village.
}
```

Maps from the 18 century showing a historical event (e.g. the French Revolution)

1: Search for "maps"

maps:Map

I am looking for: maps:Map (44 classes available)

- Things of a kind
- phen:March
- maps:Place
- maps:TopographicMap

Specify relations

Filter results by

Filter results by time window

Clear Map Clear Timeline

Zweite Periode

1650 1700 1750 1800 1850

2: Zoom to 18th cent.

maps:Map

I am looking for: maps:Map (44 classes available)

- Things of a kind
- Particular things

Specify relationship to other things (12)

Filter results by map window

Filter results by time window

Clear Map Clear Timeline

1740 1750 1760 1770

Go to time slider and set search interval by scrolling in/out. Then click this link.

3: Add map content link

maps:mapsPhenomenon

I am looking for: Things that are maps:Map connected via maps:mapsPhenomenon to something else (12 relations available)

For example: Things that are maps created by some person

- maps:digitalImageVersion
- maps:hasScale
- maps:mapSize
- maps:mapsPhenomenon
- maps:medium

Map Clear Timeline

1750 1760 1770 1780 1790 1800

Query:

```
SELECT DISTINCT ?var1 WHERE { ?var0 a maps:Map ?var0 maps:mapsPhenomenon ?var1.
```

Mediterranean_Sea

Germania

dbp-ont:Event

I am looking for: dbp-ont:Event (32 classes available)

- Things of a kind

Specify relations

Specify relations

- phen:Event
- phen:Invasion
- dbp:River
- phen:River

Clear Map Clear Timeline

Dritte Periode

Jan 1801

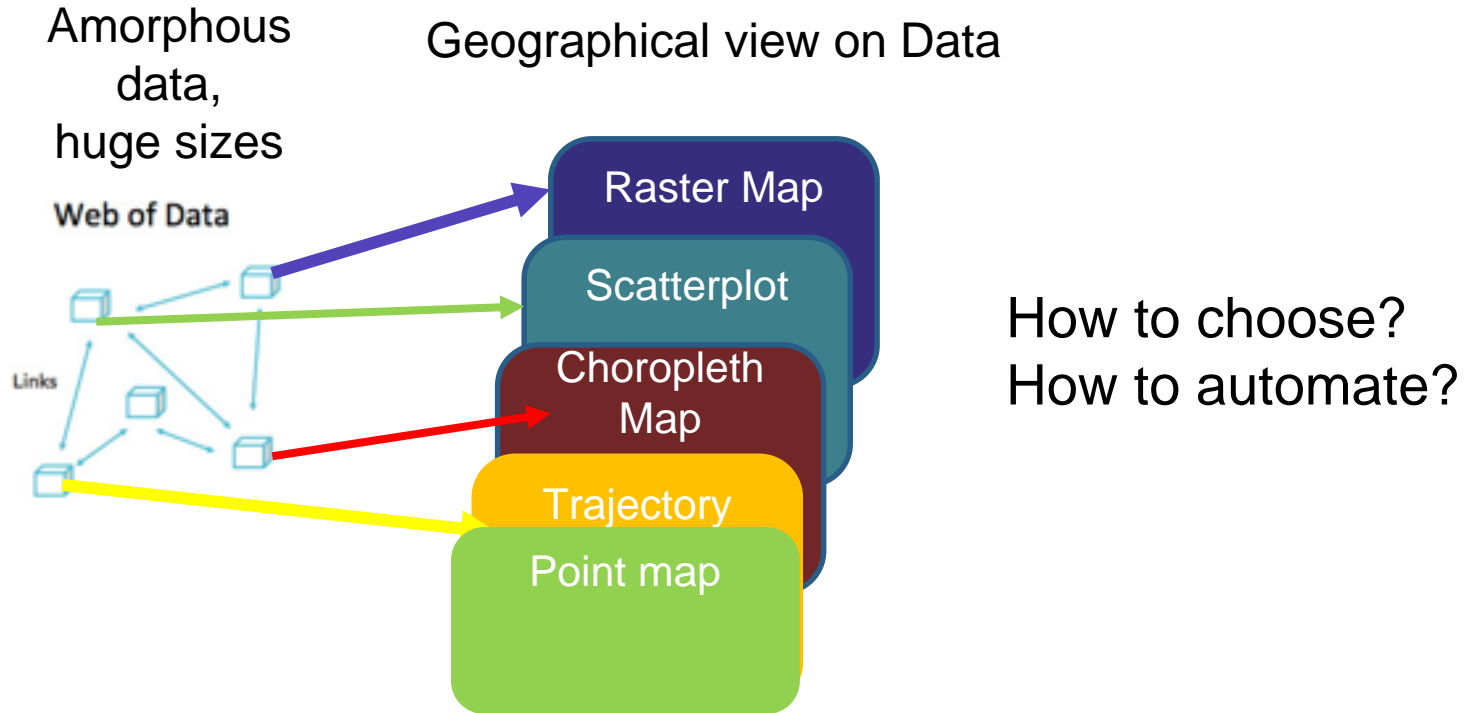
Query:

```
SELECT DISTINCT WHERE {
```

French_Revolution

4: Content Class: Event

But: The view on data changes with the analysis context



Taking referents, observation context and analysis purposes into account

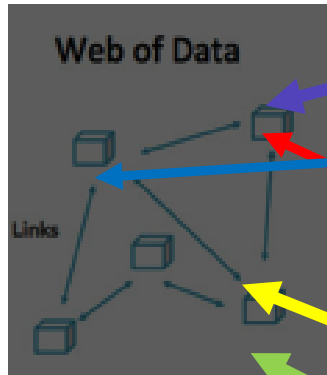
Referents

Linked data

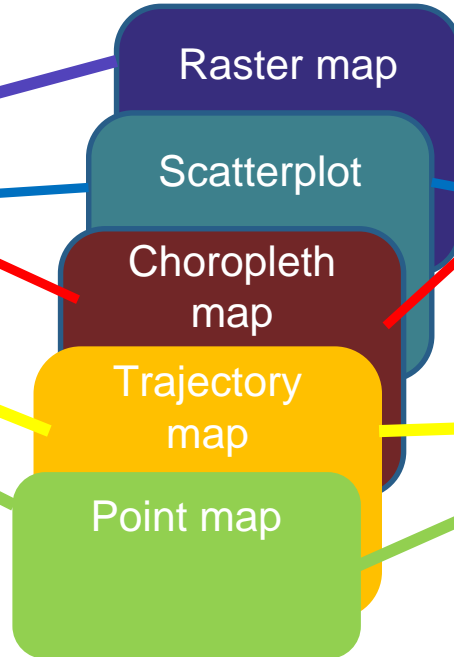
Geographical view on data

Analysis purposes

Time
Location
Quality
Object
Event



Measure Support
Observation context

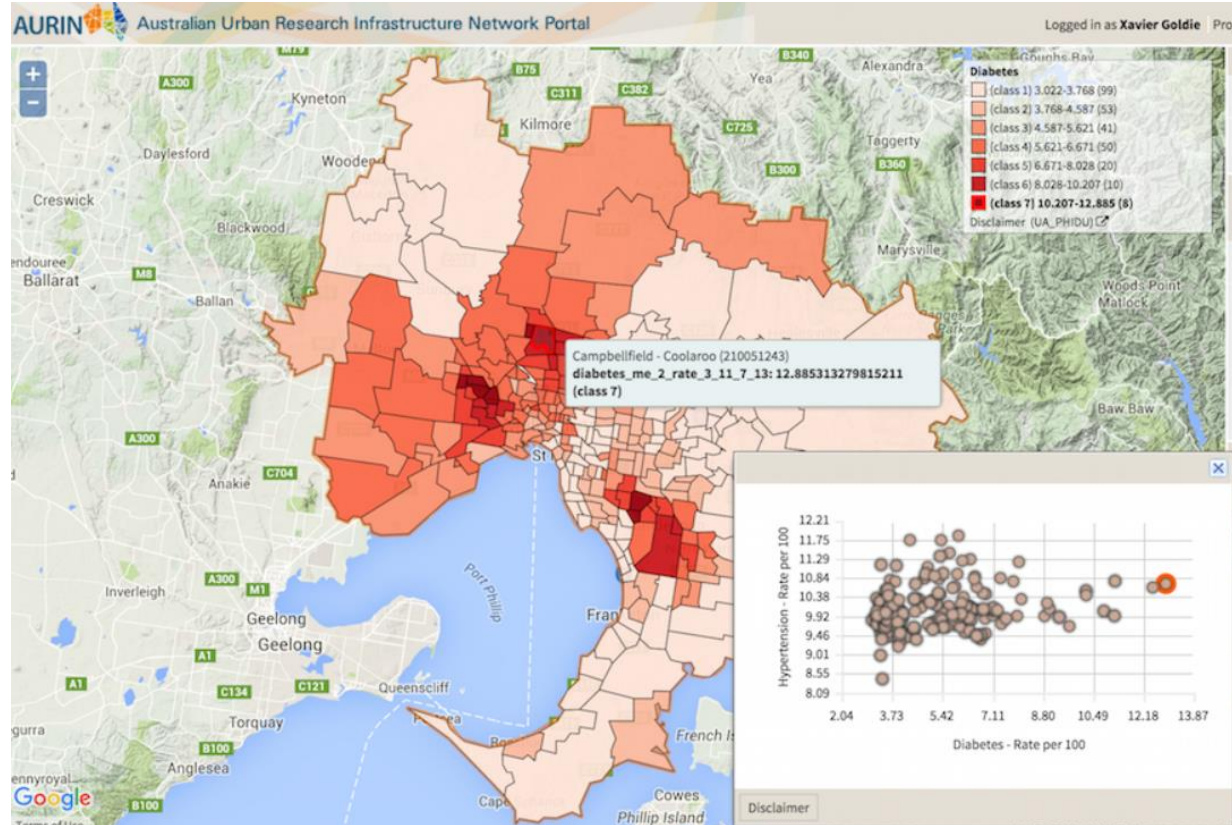


Compare values

Combine values

Compare locations
Compare times

A choropleth map and a scatterplot



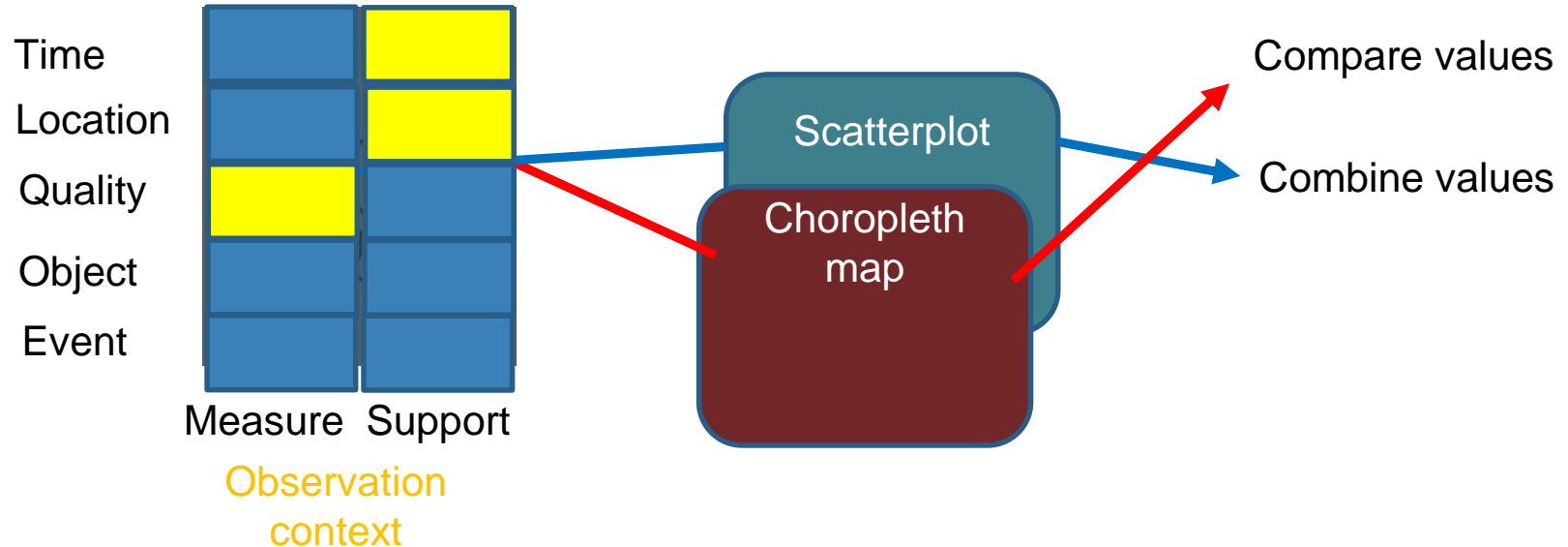
Taking referents, observation context and analysis purposes into account

Referents

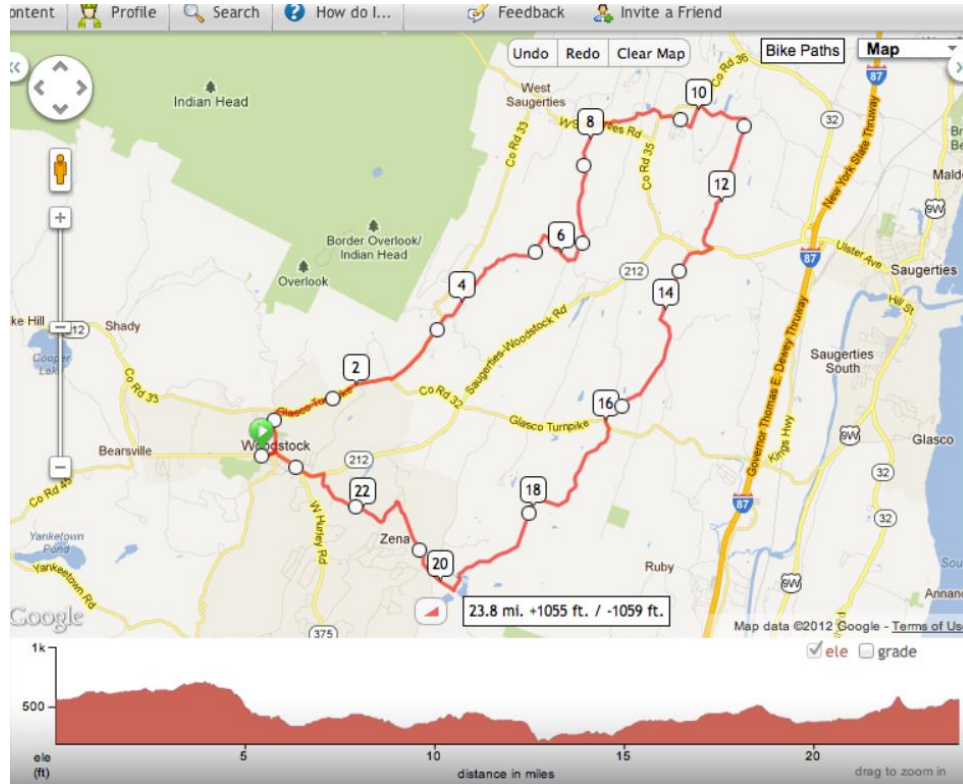
Linked data

Geographical view on data

Analysis purposes



A trajectory and point map



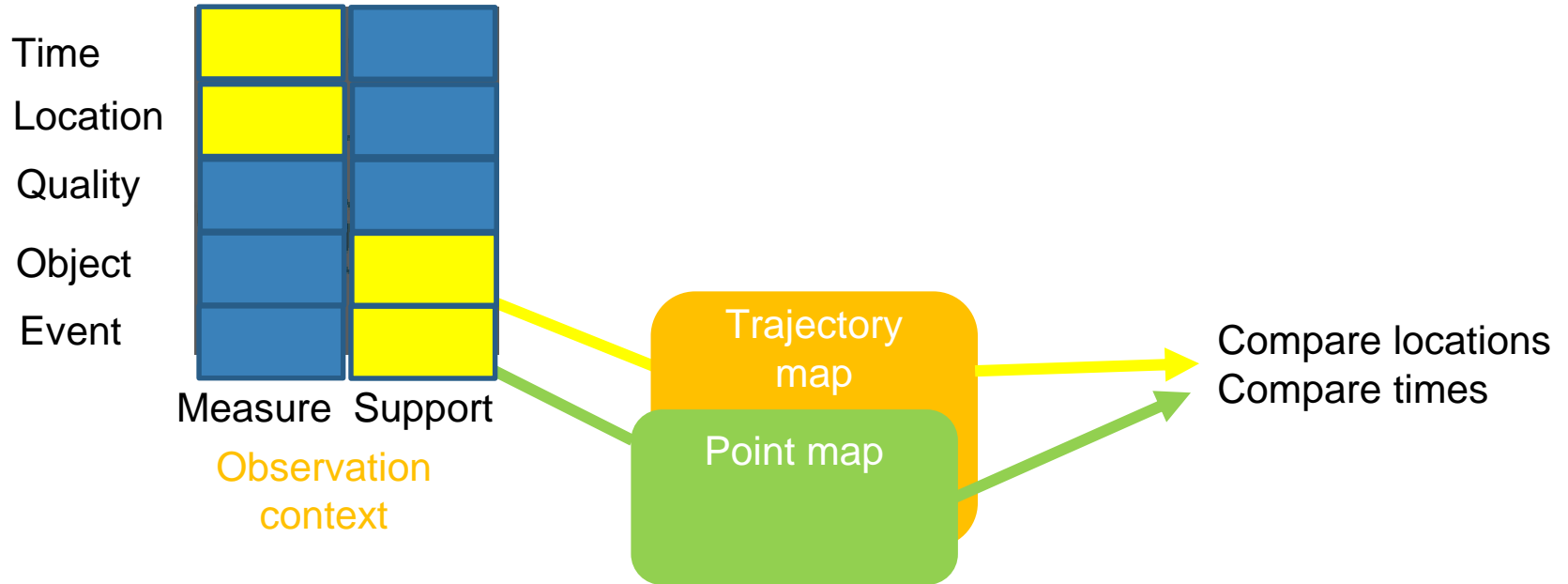
Taking referents, observation context and analysis purposes into account

Referents

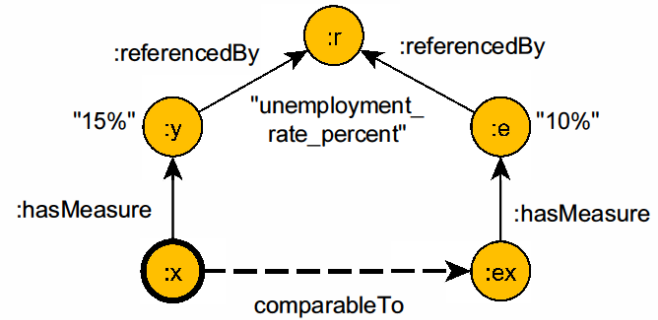
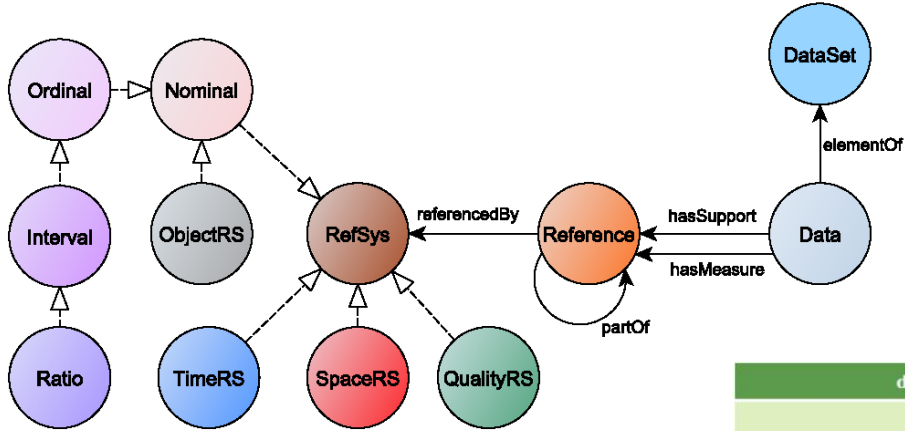
Linked data

Geographical view on data

Analysis purposes



Taking referents, observation context and analysis purposes into account



Scheider, Tomko 2016: Knowing whether spatio-temporal analysis procedures are applicable to data sets

datasetx	refSys	rlabel	datasetb
http://data.aurin.org.au/datasource/dataset-UQereseach-uq_polygons_lgas_socio_economic_variables-lga	http://data.aurin.org.au/dataset	"The percentage of the labour force which is unemployed."	http://data.aurin.org.au/datasource/dataset-VicDOH-Health_lga_profilesdata2011-LGA
http://data.aurin.org.au/datasource/dataset-ABS-ABS_CENSUS2011_B04-sa2	http://data.aurin.org.au/dataset/persons_count	"Number of people"	http://data.aurin.org.au/datasource/dataset-ABS-ABS_CENSUS2011_B07-sa2

Conclusion

A Web of data view on geographic maps

- Is produced by every geospatial linked data portal
- May help accessing map contents as well as map documents
- Requires generating (named) content graphs
- E.g. based on crowdsourcing

A geographic (map) view on the Web of data

- One fits all solution: Can be realized using maps as facets
- Or by using exploratory spatio-temporal querying
- Challenge: changing the geographic view on data depending on referents, context and analysis purposes