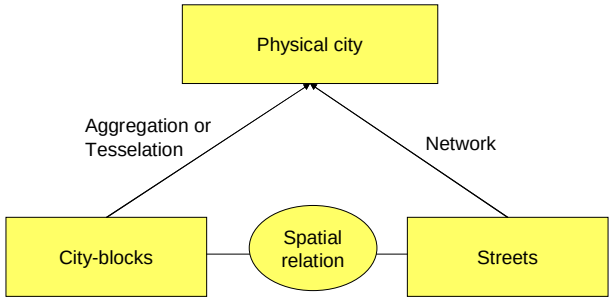
Example of ontology



Ontologies for geographic applications

- 1 – Introduction
- 2 – Theoretical bases of spatial ontologies
- 3 – Spatial relationships
- 4 – GeoOWL
- 5 – Gazetteers
- 6 – Conclusions

1 – Introduction

- Οντος = being ; Λογια = discourse
- **Aristotle:** « The study of existing objects »
- **Def1**: theory of objects and their relations
- **Def2**: theory of entities, especially of entities which exist in a language
- **Def3**: explicit specification of conceptualization (Gruber)

Guarino's definition

- **Nicola Guarino** : "*An ontology is generally regarded as a designed artifact consisting of a specific shared vocabulary used to describe entities in some domain of interest, as well as a set of assumptions about the intended meaning of the terms in the vocabulary*"

Ontological commitment

- Usually, several definitions for the same entity, for instance a horse, a table, etc.
- ➔
- Several agents/shareholders agree to a common definition of an object
- Consensus about a definition
- Shared vocabulary

Concepts

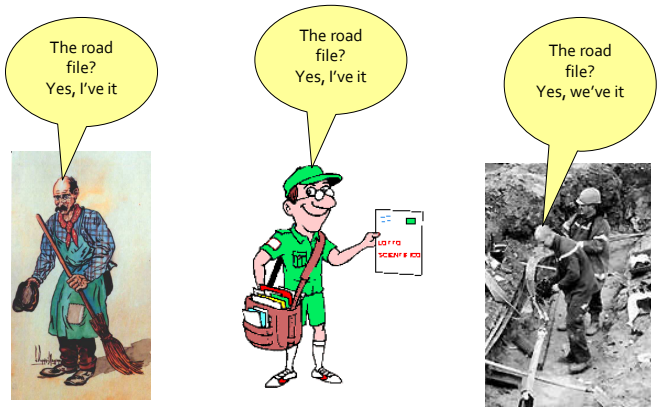
- Distinguish between terms and concepts
- At mathematical level :

Ontology = graph between concepts
= semantic network

Example about roads

- Distance (km or mile) ➔ syntactic
- Street or motorways ➔ semantic

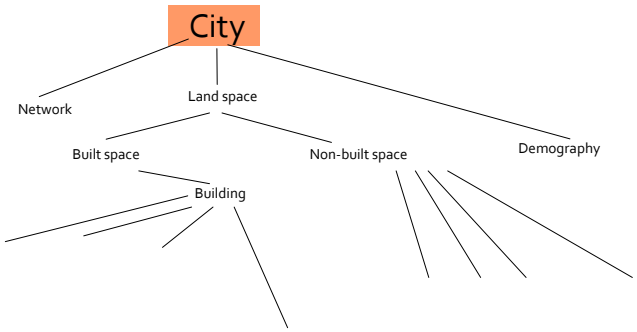
We do have the road file!



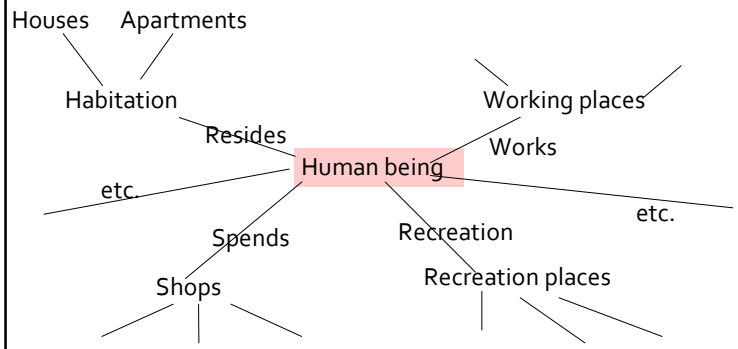
We do have the road file!

	Garbage men	Postmen	Water Supply Company
Private roads	No	Yes	??
Public roads	Yes	Yes	Generally yes
Road with water supply	?	?	Yes
Road without Water supply	?	?	No
Total	234	251	241

Beginning of an urban ontoloy



Beginning of an urban ontoloy



Examples about coast

Obj. No.	Real World phenomena - Source Terminology	Object name	Object Description			
			Attributes		Object Identity	Implementation
			Source Terminology	User Defined Attributes		Point, Line, Area or Samples
34	Coastline Shore Shoreline Shoreline movement and configuration Mean low water Mean low water (springs) Median low water mark Low water mark Low water (mean) Low water (spring) Lower tidal limit	OBJECT-COAST (MLWs - MHWs)	Heritage Coast Coastline (managed) Coastline (unspoilt) Natural Coastline Coast (undeveloped) Coast (restored) Coastline (rural) Urban coasts	Heritage Coast Developed Undeveloped	PHYSICAL ENTITY : SPATIALLY HOMOGENEOUS	VECTOR (AREA) MULTI-ATTRIBUTE
35	Point Of Closure Base line	OBJECT-CLOSURE		Depth	COGNISED ENTITY : SPATIALLY HOMOGENEOUS	VECTOR (LINE) : SINGLE ATTRIBUTE
36	Areas of Responsibility Administrative Boundaries Admin. / County Boundaries Coastal Juristdiction	OBJECT-ADMINISTRATION	Coastal cells (management) CZM unit Sea surface management areas Buffer zones Land ownership	Management Zone Land Ownership	GEOPOLITICAL ENTITY : SPATIALLY HOMOGENEOUS	RASTER : MULTI-ATTRIBUTE

Courtesy Jonathan Raper of City University London, GISci 2002 Keynote

2 – Theoretical bases of spatial ontologies

- Generic concepts
- Geographic objects
- Spatial relations
- Modeling

About Geographic Ontologies

- Two definitions
  - Conventional ontologies of geographic features (with *is-a* and *part-whole* relations)
  - Ontologies with spatial relationships between geographic features

Geographic features

- Geographic features
  - Crisp boundaries
  - Fuzzy boundaries
  - Continuous fields
- Modeling
  - Point, line, area volume
  - Multi-representations
  - Multi-scale

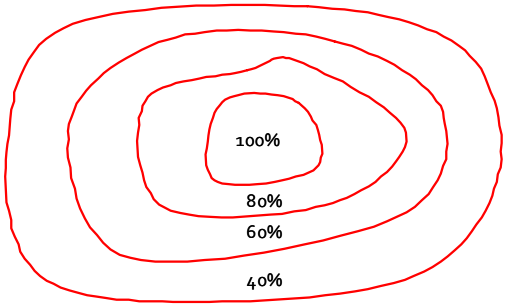
Geographic Feature Types

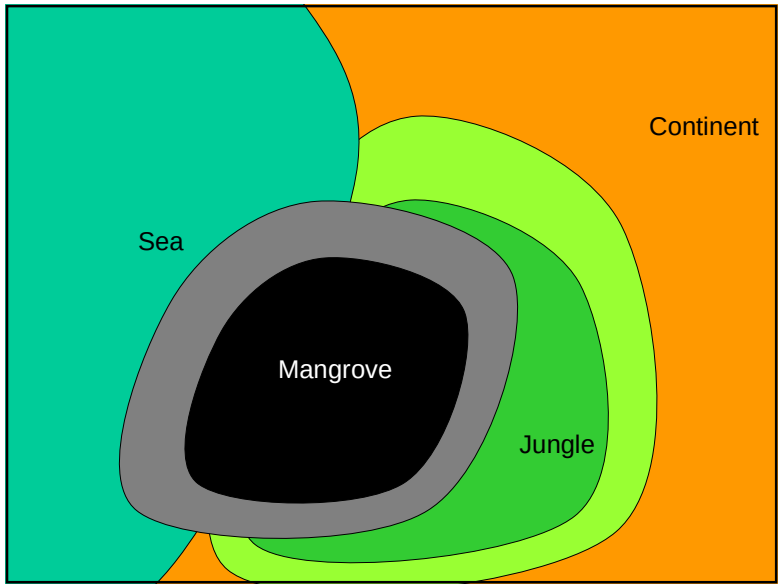
- Geodetic objects
- Administrative objects
- Human-made features
- Natural features
  - With known boundaries (crisp)
  - With unknown boudaries (fuzzy)
  - With « no » boundaries (continuous fields)

Fuzzy Geographic Objects

Membership grades (0 – 100 %)

River: Major bed, major bed





Geodetic Objects

- Theoretical objects onto the geoid
  - Equator
  - North and South Poles
  - Meridians
  - Parallels
- Modeled by points and circles
- Basis for coordinates

Administrative objects

- No ligitations at boundaries
- Non-connex planar polygons (2D)
- Often in hierarchical tesselations
  - Countries, regions, provinces, cities
  - Natural parks
- Total coverage of the globe
- At some scale, some objects can disappear

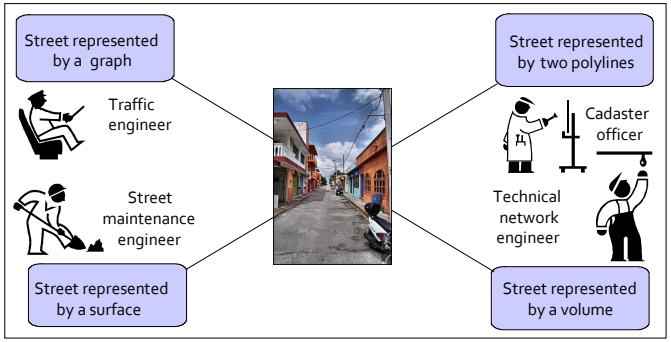
Human-made features

- Made by humans
  - Parcels, buildings, streets, bridge, tunnels, etc.
- Modeled by non-connex polygons (2D) or polyhedra (3D)
- At some scale, roads are linear

Object geometry

- Only one storing structure
- But many layout (mapping) structure issued by generalization
- When layout geometry < threshold, then object will disapear

Multiple representation



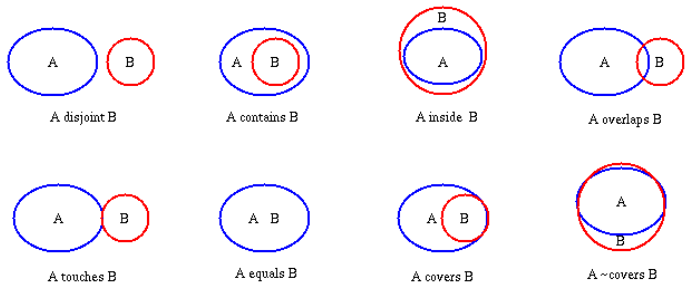
3 – Spatial relationships

- Conventional spatial relations
- New spatial relations

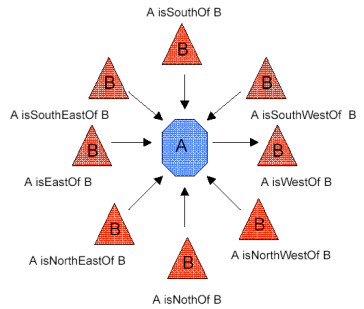
Spatial relations

- Topological (Allen, Egenhofer, Clementini, etc.)
- Projective (cardinal)
- Distances

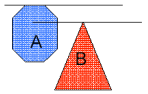
Egenhofer relations



Projective relations

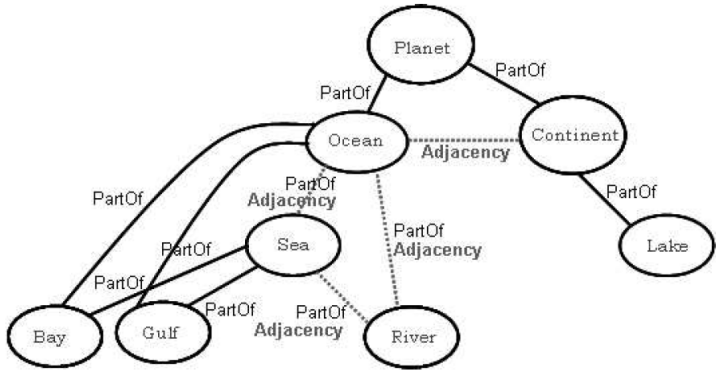


e.g. "*A isNorthOf B*"

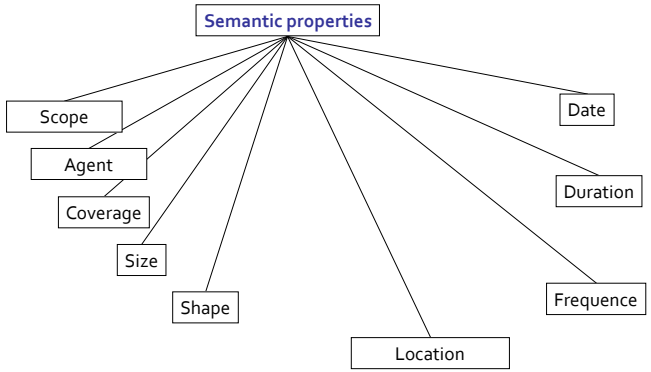


True if northern most point of A is north of the northern most point of B

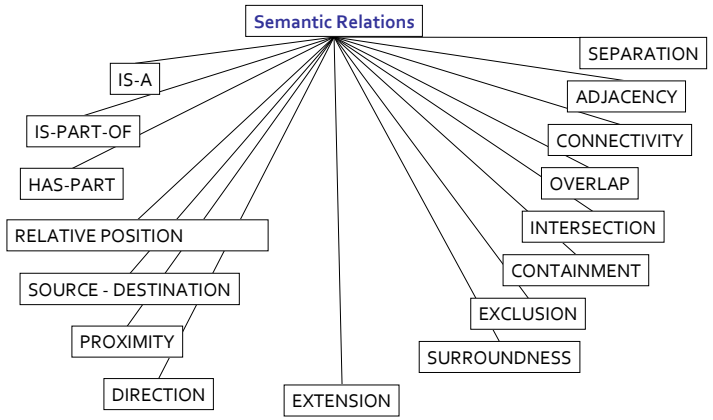
Examples of spatial relations



Main semantic properties of geographic concepts



Main semantic relations of geographic concepts



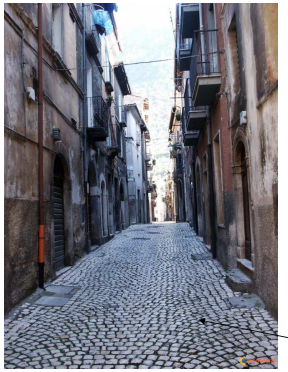
Jungert operators (1/2)

A<B	center(A) < center(B)	A B
A=B	center(A) = center(B)	AB
A|B	Side by side	A B
A%B	Min(A) > Min (B) Max(A) < Max (B) Length(A) < Length(B)	A B

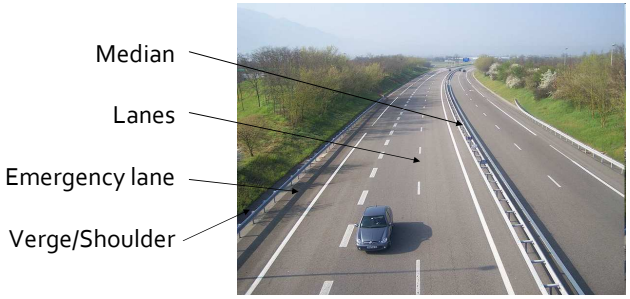
Jungert operators (2/2)

A[B	Min(A) = Min (B) Length(A) < Length(B)	A B
A]B	Max(A) = Max (B) Length(A) < Length(B)	A B
A\B	Min(A) < Min (B) Length(A) ≤ Length(B)	A B
A/B	Max(A) > Max (B) Length(A) ≤ Length(B)	A B

Streets



Motorway

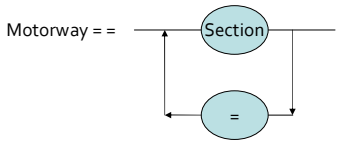


New spatial relations (2D)

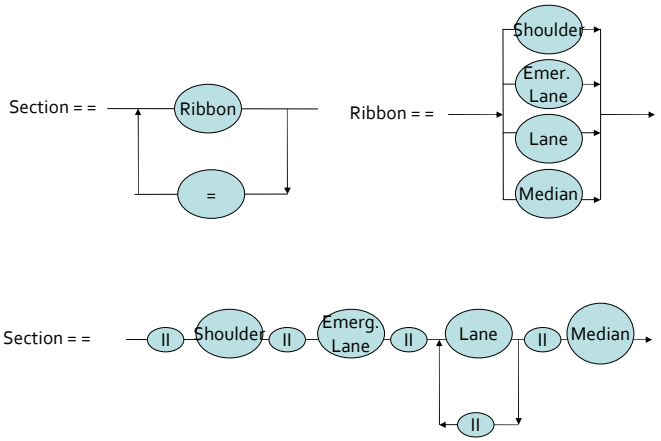
- Horizontally
  - Ribbon
  - Relations
- End-to-end noted =
- Side-by-side noted ||

Motorway

- Example: Motorway
  - Divided into « sections » End-to-end
  - Each section divided into « ribbon » Side-by-side

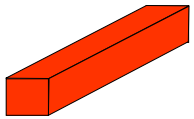


Sections

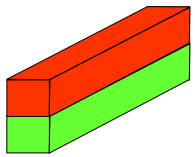


New spatial relations (3D)

- Vertically
  - layer

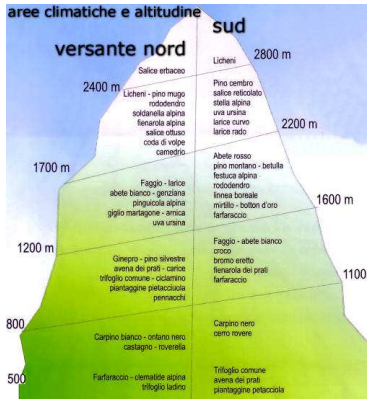


  - Relations
- Bottom-to-top
- Top-to-bottom
- End-to-end
- Side-to-side



==> Geology
Buildings

Mountain



Vegetation layers

- Fuzzy layers
- As 3D objects (bottom-to-top)
- As 2D surfaces (side-by-side)

4 – GeoOWL

- OWL: Ontology Web Language
- Geographic ontology based on OWL
- 8 million names for 6.5 million features
- Modeling aspect
- Links with avec GeoNames
  - Placenames (toponyms)
  - Name of features (in English)

Key-concepts of GeoOWL

```
<owl:Class rdf:about="&gml;/_Feature" />
<owl:Class rdf:about="&gml;/_Geometry" />
<owl:Class rdf:about="&gml;/Point">
<owl:Class rdf:about="&gml;/Polygon">
<owl:Class rdf:about="&gml;/Envelope">
<owl:Class rdf:about="&gml;/LineString">
<owl:Class rdf:about="&gml;/LinearRing">

<owl:ObjectProperty rdf:about="&geo;/where">

<owl:DatatypeProperty rdf:about="&gml;/pos">

<owl:DatatypeProperty rdf:about="&gml;/posList">

<owl:Class rdf:about="&gml;/Point">
<owl:Class rdf:about="&gml;/LineString">
<owl:Class rdf:about="&gml;/LinearRing">

<owl:ObjectProperty rdf:about="&gml;/exterior">

<owl:DatatypeProperty rdf:about="&gml;/lowerCorner">
<owl:DatatypeProperty rdf:about="&gml;/upperCorner">
<owl:DatatypeProperty rdf:about="&gml;/featurename">
<owl:DatatypeProperty rdf:about="&gml;/featuretypetag">
<owl:DatatypeProperty rdf:about="&gml;/relationshiptag">

<owl:DatatypeProperty rdf:about="&geo;/point">
<owl:DatatypeProperty rdf:about="&geo;/line">
<owl:DatatypeProperty rdf:about="&geo;/polygon">
<owl:DatatypeProperty rdf:about="&geo;/box">

<owl:DatatypeProperty rdf:about="&geo;/elev">

<owl:DatatypeProperty rdf:about="&geo2003;#lat">
<owl:DatatypeProperty rdf:about="&geo2003;#long">
```

GeoNames

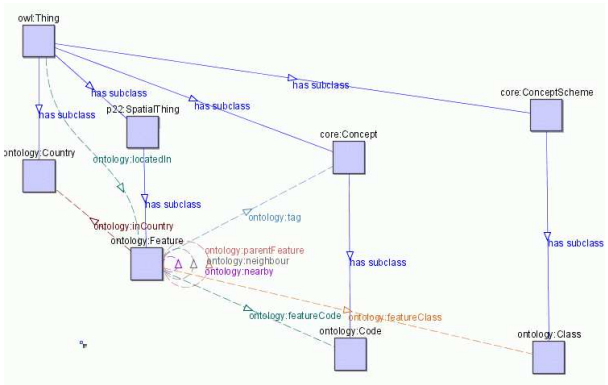
Sub-classes

- ontology:A country, state, region
- ontology:H (water bodies)
- ontology:L (parks, areas)
- ontology:P city, village
- ontology:R road, railroad
- ontology:S spot, buildings, farms,
- ontology:T mountain, hill, rock
- ontology:U undersea
- ontology:V forest, heath

Excerpt from the list of geographic concepts

- DTCH ditch a small artificial watercourse dug for draining or irrigating the land
- DTCHD drainage ditch a ditch which serves to drain the land
- DTCHI irrigation ditch a ditch which serves to distribute irrigation water
- DTCHM ditch mouth(s) an area where a drainage ditch enters a lagoon, lake or bay
- ESTY estuary a funnel-shaped stream mouth or embayment where fresh water mixes with sea water under tidal influences
- FISH fishing area a fishing ground, bank or area where fishermen go to catch fish
- FJD fjord a long, narrow, steep-walled, deep-water arm of the sea at high latitudes, usually along mountainous coasts
- FJDS fjords long, narrow, steep-walled, deep-water arms of the sea at high latitudes, usually along mountainous coasts
- FLLS waterfall(s) a perpendicular or very steep descent of the water of a stream
- FLLSX section of waterfall(s)
- FLTM mud flat(s) a relatively level area of mud either between high and low tide lines, or subject to flooding
- FLTT tidal flat(s) a large flat area of mud or sand attached to the shore and alternately covered and uncovered by the tide
- GLCR glacier(s) a mass of ice, usually at high latitudes or high elevations, with sufficient thickness to flow away from the source area in lobes, tongues, or masses
- GULF gulf a large recess in the coastline, larger than a bay

GeoNames Ontology



URI

- Ex. : for Cagliari, there are 2 URI

1: City:

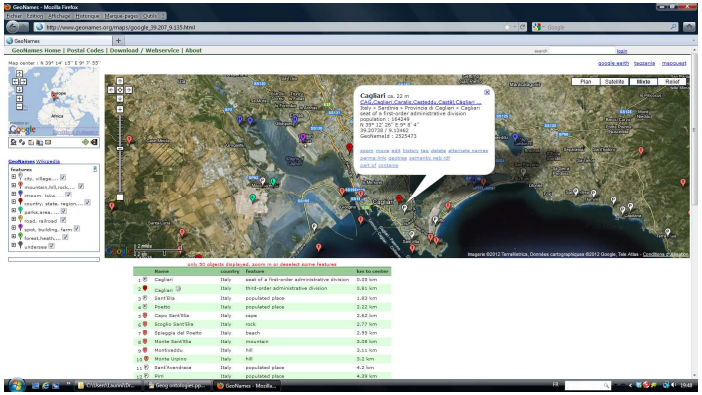
http://www.geonames.org/maps/google_39.207_9.135.html

2: Province:

http://www.geonames.org/maps/google_39.245_9.091.html

  - 1 : location
  - 2 : information

http://sws.geonames.org/3020251/



Linked data

- Components of Italy (contains) : http://www.geonames.org/3175395/contains.rdf
- Neighboring countries of Italy (neighbours) : http://www.geonames.org/3175395/neighbours.rdf
- Geographic features (For example, the Eiffel Tower) http://sws.geonames.org/6254976/nearby.rdf

http://www.geonames.org/3175395/neighbours.rdf

```
- <rdf:RDF>
  - <gn:Feature rdf:about="http://sws.geonames.org/3017382/">
      <rdfs:isDefinedBy>http://sws.geonames.org/3017382/about.rdf</rdfs:isDefinedBy>
      <gn:name>France</gn:name>
      <gn:neighbour rdf:resource="http://sws.geonames.org/3175395/"/>
    </gn:Feature>
  - <gn:Feature rdf:about="http://sws.geonames.org/2658434/">
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      <gn:name>Switzerland</gn:name>
      <gn:neighbour rdf:resource="http://sws.geonames.org/3175395/"/>
    </gn:Feature>
  - <gn:Feature rdf:about="http://sws.geonames.org/2782113/">
      <rdfs:isDefinedBy>http://sws.geonames.org/2782113/about.rdf</rdfs:isDefinedBy>
      <gn:name>Austria</gn:name>
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    </gn:Feature>
  - <gn:Feature rdf:about="http://sws.geonames.org/3190538/">
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      <gn:name>Slovenia</gn:name>
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    </gn:Feature>
</rdf:RDF>
```

GeoNames Services

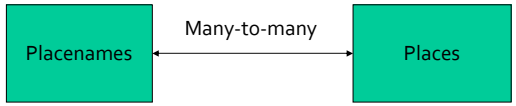
- 1 astergdem
- 2 children
- 3 cities
- 4 countryCode
- 5 countryInfo
- 6 countrySubdivision
- 7 earthquakes
- 8 extendedFindNearby
- 9 findNearby
- 10 findNearbyPlaceName
- 11 findNearbyPostalCodes
- 12 findNearbyStreets
- 13 findNearByWeather
- 14 findNearbyWikipedia
- 15 findNearestAddress
- 16 findNearestIntersection
- 17 get
- 18 gtopo30
- 19 hierarchy
- 20 neighbourhood
- 21 neighbours
- 22 ocean
- 23 postalCodeCountryInfo
- 24 postalCodeLookup
- 25 postalCodeSearch
- 26 rssToGeo
- 27 search
- 28 siblings
- 29 srtm3
- 30 timezone
- 31 weather
- 32 weatherIcao
- 33 wikipediaBoundingBox
- 34 wikipediaSearch

5 – Gazetteers

- Gazetteer = dictionary of placenames
- What to store:
  - Names with variants along time
  - Names in different languages
  - Geometry (varying)
  - Feature type
  - Neighbors
  - Rivers: confluence

Examples

- Byzantium, Constantinople, Istanbul
- Roma of Romulus and of today
- Cagliari, city or province
- Etc



Cagliari	English
Cagliari	Spanish
Cagliari	French
Cagliari	Italian
Càgliari	Sicilian
Càller	Aragonese
Càller	Catalan
Caralis	Latin
Casteddu	Italian
Casteddu	Sardinian
Castèl	Occitan
كالياري	Arabic
יראילק	Hebrew
Кальяри	Russian
Кальари	Serbian

Geonaming

- From the coordinates of a place, assigning a name to this place
  - line
  - area
- Problems of linguistics
  - multilingual problem
- What name?
  - Name in the official language of the country
  - Name in the language of the user
  - Name in the language of the system

Generic tables

```
Names (idn, text)

Category (idc, category-type)

Geometry (idn, idc, date, not-connected-polygon)

Other-names (idn1, idn2, type, language)
```

Geographic Ontology

For municipalities

```
Belongs-to (idn, date, country-name)

Population (idn, date, poulation)

Neighbours (idn, (neighbouring-municipalities)*)
```

For countries

```
Population (idn, date, poulation)

Neighbours (idn, (neighbouring-countries)*)
```

For rivers

```
Confluence (idn, main-confluent-river-idn)
```

6 – Conclusions

- Ontologies as tools
  - For interoperability
  - For clarifying vocabulary
- Difficulties to properly define geographic features
  - Semantically
  - Geometrically
  - Topologically
- Importance of spatial relationships
  - Possibly of using new spatial relations
- Links with gazetteers
- Geographic ontologies (with spatial relationships)