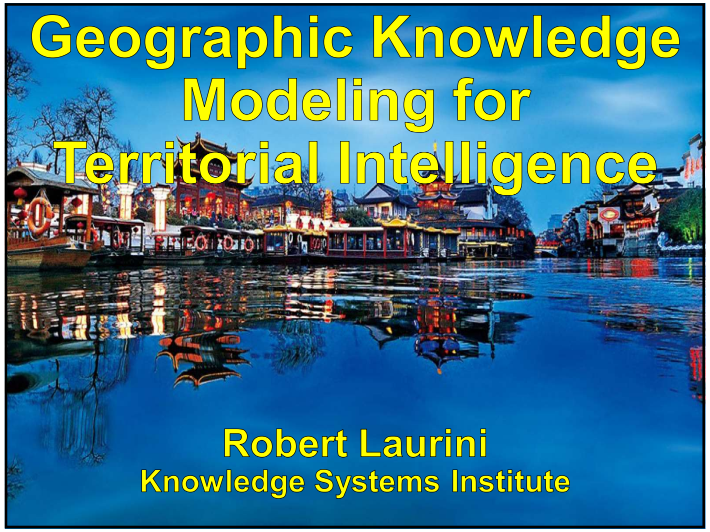
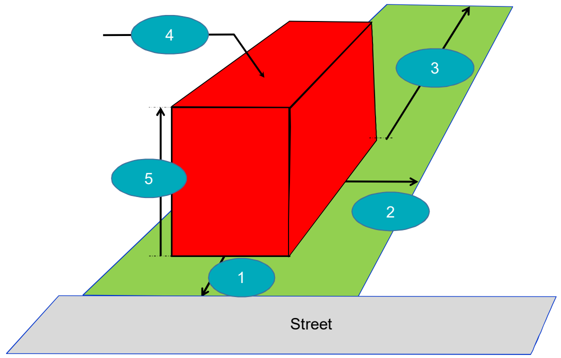


Urban Planning Rules



Encoding

$\forall B \in PROJECT, \exists P \in GO$ $\Omega\text{-}Type\ (B) =$ "Building", $\Omega\text{-}Type\ (P) =$ "Parcels", $Contains\ (Geom\ (P), Geom\ (B))$: $Height\ (B) < 10$ $\wedge Street\_distance\ (B, P) > 3$ $\wedge Neighbor\_distance\ (B, P) > 3$ $\Rightarrow$ $UP\text{-}Allowed\ (B, P)$	Rule 10.9-10.13

Geographic Knowledge Modeling for Territorial Intelligence

1 – Introduction

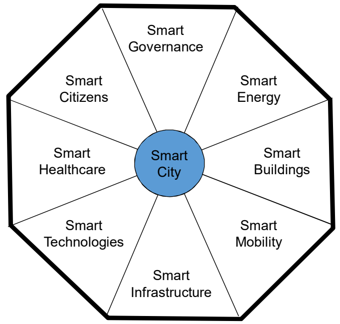
2 – Components of a GKB

3 – Conclusions

1 – Introduction

- Information
  - Geographic information systems (80s)
  - Fundamentals of Spatial Information Systems (Laurini-Thompson, 91)
  - “Information Systems for Urban Planning” (Laurini, 01)
- Now Knowledge
  - Business intelligence to Territorial Intelligence
  - Knowledge society

Mathew’s diamond for smart cities



Territorial Intelligence

Territorial Intelligence
=
(Territory
+
Collective Human Intelligence
+
Artificial Intelligence)

➔ Sustainable development)

About Knowledge

- Knowledge Society
- Basis for governance
  - Smart Cities
  - Territorial Intelligence
- Difference between data, information and knowledge
- Neighboring concepts
  - Smart People
  - Smart Governance

New Context

- New acquisition devices
  - Real time sensors
  - Crowd sourcing
  - VGI
  - Big Data
- New concepts
  - Smart cities
  - Territorial Intelligence
- Reorganize information systems in local authorities
- Importance of geographic reasoning

Definition of Geographic Knowledge

- Geographic knowledge corresponds to information potentially useful to
  - explain,
  - manage,
  - monitor
  - and plan a territory.
- But also to
  - analyze the past
  - forecast the future landscapes

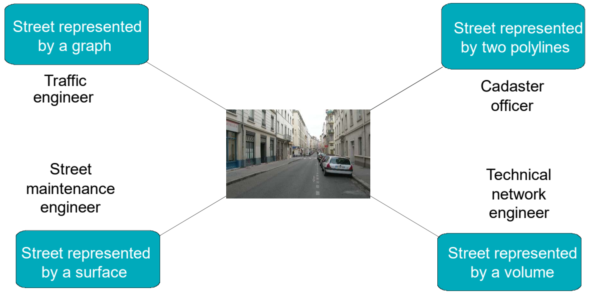
Geographic Knowledge

- RULES as first-class citizens in IT
  - IF-THEN-Fact
  - IF-THEN-Actions
- Business intelligence (1^{st} order logic)
- Territorial Intelligence
  - Rewrite geoprocessing based on rules
  - Renovate concepts
- New types for geographic rules

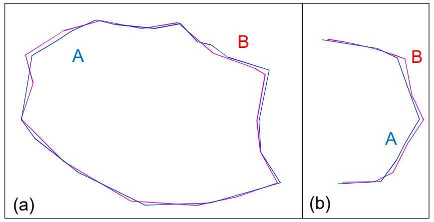
Specific Characteristics

- Space 2D, 3D, 3D+T → coordinates
- Computational geometry, topology
- Cartography and geovisualization
- Spatial analysis
- Features and geographic objects
  - Measurement accuracy
  - Multiple representations
  - Acquisition devices

Example of a Street



Geometric Homology



$Geom(A) \approx Geom(B)$

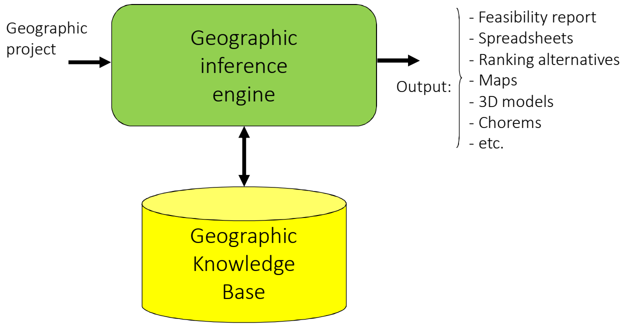
Reflexive, associative

But non-transitive

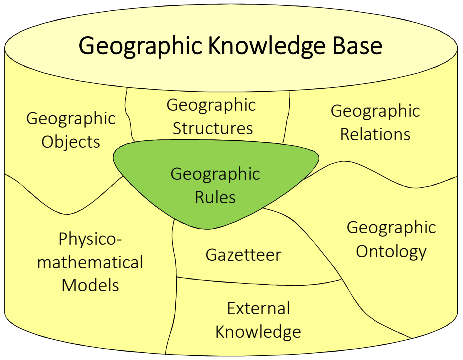
Geographic Projects

- Where to put a new airport, a new hospital, a new stadium, etc.?
- Is this new construction project compliant with planning rules?
- What is the best mode or the best way to get from *A* to *B*?
- How to organize a plan for green spaces in a city?
- How to reorganize common transportation?
- etc.

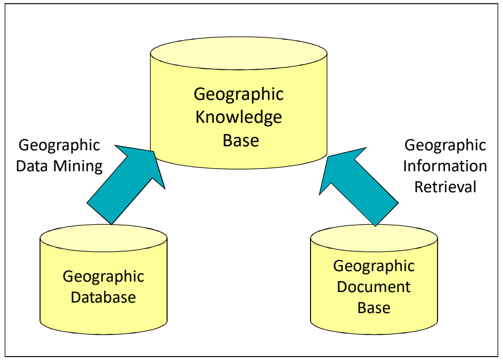
Usage



2 – GKB Components



Origin of Geographic Knowledge

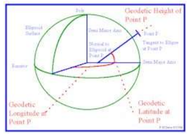


2.1 – Geographic Objects

- Geodetic objects
- Administrative objects
- Manmade objects (crisp boundaries)
- Natural objects
- With fuzzy boundaries
- Continuous fields

Geodetic Objects

- Theoretical objects on the globe
  - Equator
  - North and south poles
  - Meridians
  - Parallels



- Modeled with points, lines and circles
- Basis for definition of coordinates
- Cannot disappear

Administrative Objects

- Without considering disputes at borders
- Non-connected polygons
- Often organized in hierarchical tessellations
  - Countries, regions, provinces, municipalities
  - Parks
- Total coverage of the Earth
- A some scales, they can disappear

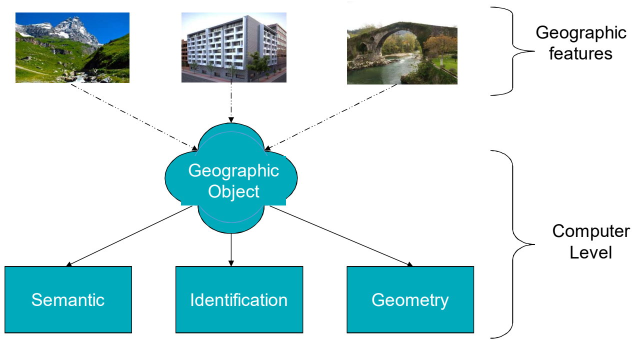
Manmade Objects

- Manmade
  - Buildings, bridges, streets, etc.
- Usually Euclidean objects
- Modeled as non-connected polygons
- At some scales
  - Roads can become linear
  - They can disappear

Natural Objects

- Shape can evolve
  - River, minor and major bed
- Boundary not easy to define
- Fractal geometry can be useful
  - Multi-scale
- Fuzzy sets
  - Egg-yolk

Characteristics of Geo Objects



What is it?

(a) A car park? No, the roof of a small used as a car park.

(b) A meadow? No, a water catchment area

Geometric Types

- Math tradition
  - Points
  - Lines
  - Areas

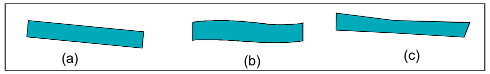
For mathematical modeling

- Proposition
  - Ribbons
  - Areas

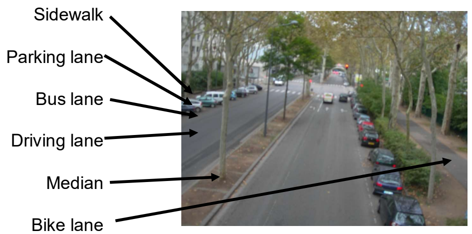
For geographic modeling

From Lines to Ribbons

- Ribbon = line with a width
- Rectangular Ribbons
- Loose Ribbons
- Fuzzy Ribbons

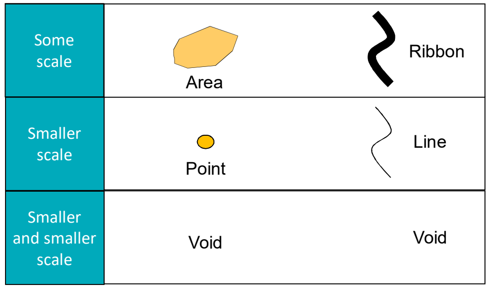


Modeling a Street with Ribbons



Sidewalk
Parking lane
Bus Lane
Driving lane
Median
Driving lane
Bike lane
Sidewalk

General Process



Disappearance of a Geographic Object

- Geographic object (*O*) at scale σ noted O^σ

$\forall O \in GO, \forall \sigma \in Scale$, G-$Type(O) = Area$, $O^\sigma \equiv 2Dmap(O, \sigma)$: $Area\ (O^\sigma) < (\varepsilon_{lp})^2$ $\Rightarrow$ $O^\sigma = \varnothing$.	Rule 4.1

Transformation of an Area into a Point

$\forall O \in GO, \forall \sigma \in Scale$, G-$Type(O) = Area$, $O^\sigma \equiv 2Dmap(O, \sigma)$: $(\varepsilon_i)^2 < Area\ (O_\sigma) < (\varepsilon_{lp})^2$ $\Rightarrow$ {G-$Type(O^\sigma) = Point$; $O^\sigma = Centroid(O)$}	Rule 4.2

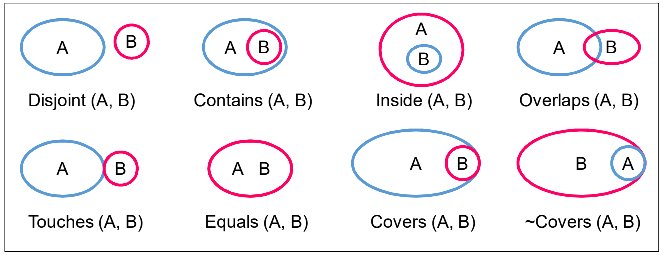
Final Remarks Concerning Geographic Objects

- $GO \equiv \{O_1, O_2, \ldots O_n: n \in N\}$.
- $O_i \equiv$ (*GeoID*$_i$, G-*Type*$_i$, *Topo*$_i$, *Geom*$_i$, Ω-*Type*, (*Attribute*, *Value*)*)
- G-*Type* ∈ {*Point*, *Line*, *Area*, *Ribbon*, *Void*, *Null*}.
- Modifiers
  - *Crisp* and *Fuzzy* for points, lines, ribbons and areas
  - *Oriented* or *Not_Oriented* for lines and ribbons.

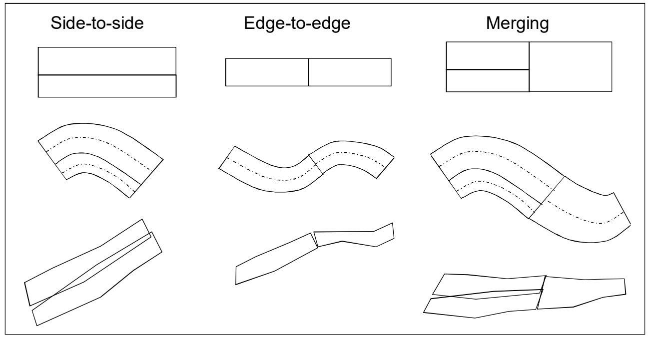
2.2 – Geographic Relations

- Not only spatial relations (Egenhofer)
- Geographic relations can vary according to scale
- Ribbon relations

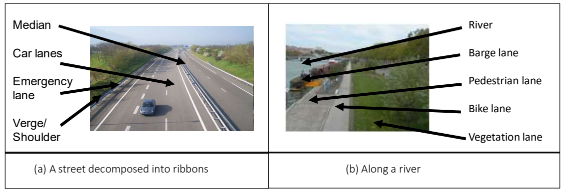
Egenhofer Relations



Ribbon Relations



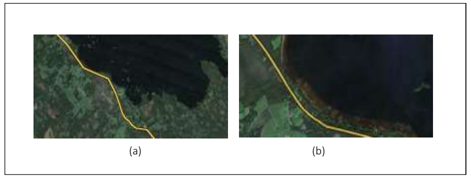
Examples



SIDE_BY_SIDE (Platform, railways)
SIDE_BY_SIDE (Bus_stop, Bus_lane)
SIDE_BY_SIDE (Levee, River)
SIDE_BY_SIDE (Towpath, River).

Scales

- According to scale, relations vary

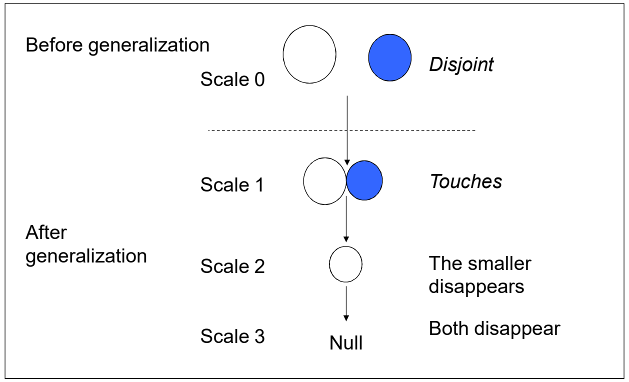


- Touches or Disjoint?

Mutation of Topological Relations

- Example of Topological Mutation due to Granularity of Interest
- Mutation Table of Egenhofer Relations
- Mutation of Ribbon Relations

Example of Mutation

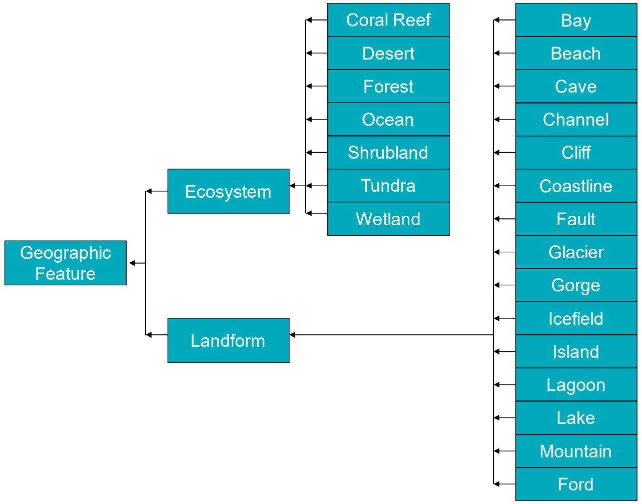


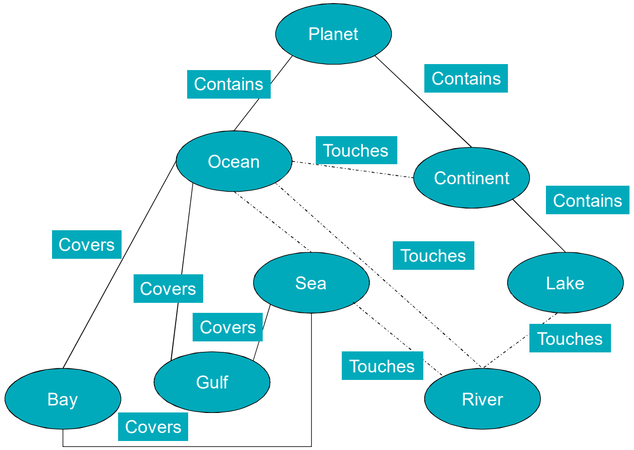
2.3 – Geographic Ontologies

- Organizations of geo features
- In addition to relations "*is_a*", "*has_a*", "*whole_part*"
  - Necessity of spatial relations

Example of Ambiguities

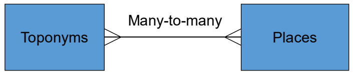
French	Picture	English	Spanish	Italian
Quai		Warf	Muelle	Molo
		Riverside	Avenida a lo largo de un río	Lungofiume
		Platform	Andén	Binario





2.4 – Gazetteers

- Placenames / toponyms
- Can change over time
- Multiple translations
- Different places can have same name



- Not only cities, but also streets and landmarks

Some Problems Regarding Toponyms

- "Mississippi" can be the name of a river or of a state.
- The city, "Venice", Italy, is also known as "Venezia", "Venise", "Venedig", respectively, in Italian, French and German.
- The local name of the Greek city of "Athens" is "Αθήνα"; read [a'θina].
- "Istanbul" was known as "Byzantium" and "Constantinople" in the past.
- The modern city of Rome is much bigger than in Romulus's time.

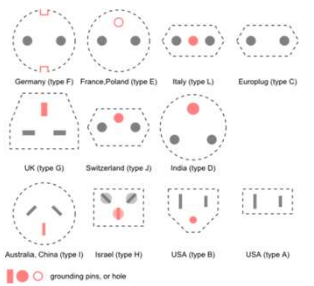
2.6 – Geographic Rules

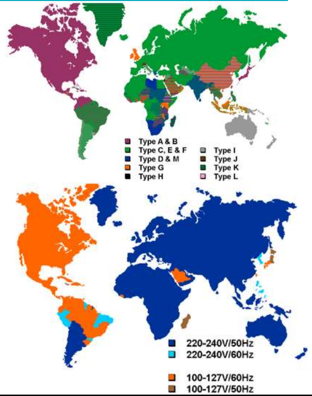
- in the United Kingdom, we drive on the left;
- in Canada, the majority of the population lives along the border with the United States;
- each capital city has an international airport nearby;
- between the two capital cities, in general, there are direct flights;
- in the Northern Hemisphere, the more you are going to the north, the colder (but locally this is not always true).

Examples of Geographic Rules

- the more you climb a mountain, the colder;
- heavy rain upstream, downstream flooding.
- mosques are oriented towards Mecca;
- if a zone is a swamp, it is necessary to prohibit construction;
- if there is unemployment, the creation of companies or industrial areas must be encouraged;

Decision Trees, Tables and Maps



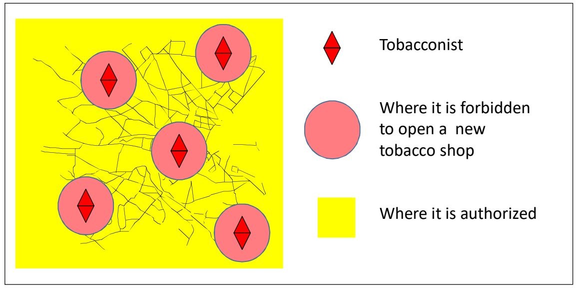


http://wikitravel.org/en/Electrical_systems

Different Types of Geographic Rules

- Applicative rules
  - Urban and Environmental Planning
  - Transportation
  - Tourism, etc
- Generic rules (to ensure reasoning robustness)
  - Quality control
  - Independence from data acquisition devices
  - Taking human languages and reasoning into account
  - Variation according scales (mutation of shapes, relations, etc.)

Tobacco Shop Rule in France



Zone Determination

$$\forall F_i \in GO, \exists Z \in Terr,$$
$$\text{G-}Type\ (F_i) = Point,\ \text{G-}Type\ (Z) = Area,$$
$$\Omega\text{-}Type\ (F_i) = \text{“Tobacconist”},$$
$$Geom\ (F_i) \in Terr$$
$$\Rightarrow$$
$$Geom(Z) = Terr - Union\ (Buffer\ (F_i,\ 500)) \qquad \text{Rule 10.8}$$

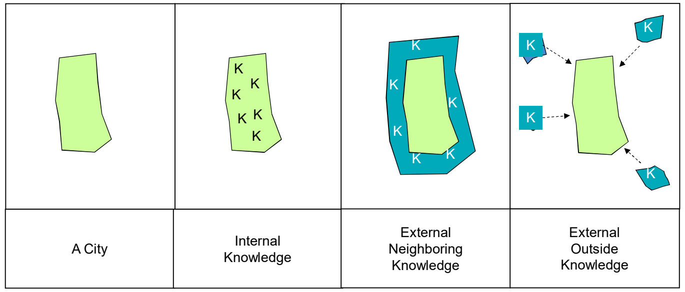
Urban Planning Rules

- Rule 1: If a zone is a marsh or floodplain then prohibit construction.
- Rule 2: If there is unemployment then support the creation of businesses and/or create industrial zones.
- Rule 3: If a plot is adjacent to an airport then limit the height of the building.

2.7 – External Knowledge

- In GIS, usually coverage = spatial extension of the jurisdiction of the owning entity
- Importance of the vicinity
- Two kinds of external knowledge
  - At the vicinity of the jurisdiction
  - Technology watching
- “intra muros” and “extra muros” knowledge

External Knowledge



4 – Conclusions

- 80 % of data in the world have some geographic basis
- Only a rapid presentation of geographic knowledge in urban planning
- Territorial intelligence more complex than business intelligence
- Many additional aspects must be developed
  - 3D, time
  - Computer language
  - Geographic inference engine

Main recent references

- LAURINI R. (2014) "***A Conceptual Framework for Geographic Knowledge Engineering***", Journal of Visual Languages and Computing, Volume 25, pp.2-19.
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- LAURINI R., KAZAR O. (2016) "***Geographic Ontologies: Survey and Challenges***" Journal for Theoretical Cartography (Vol. 9; 2016), ISSN 1868-1387, pp. 1-13.
- LAURINI R, FAVETTA F (2017) "***About External Geographic Information and Knowledge in Smart Cities***". 2nd International Conference on Smart Data and Smart Cities, 4–6 October 2017, Puebla, Mexico. The International Archives of the Photogrammetry, Remote Sensing and Spatial Information Sciences, Volume XLII-4/W3, 2017.

Main book

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