« 80% of the data throughout the world have some geographic basis »

New Perspectives in GIS Databases

- I – Emerging needs
- II – Current research directions
- III – New Earth-wide projects
- IV – Final remarks

I – Emerging needs

- Location-based services (LBS)
- Real time GIS
- 3D modeling
- New decision-support systems
- GIS for public participation (PPGIS)
- Interoperability
- Web GIS

Location-based services (LBS)

- PDA
- GPS, RFID, etc.
- Domains
  - Pervasive and mobile applications
  - *m*-tourism
  - etc.
- Hotspots – Antenna
- Service discovery
- Caching systems

Real time GIS (RTGIS)

- Domains
  - Telegeoprocessing
  - LBS applications
  - Disaster preparedness
  - Risk monitoring
- Necessity of handling geodata in real time

3D databases

- Domains
  - 3D cadasters
  - Geology
  - Galleries – tunnels
  - Archaeology
- Necessity of 3D models, 3D topology
- CityGML

New decision-support systems

- Domains
  - Crisis team
  - Etc.
- Decision in real time
- Robustness, efficiency

GIS for public participation (PPGIS)

- Domains
  - Urban planning
  - Environmental planning
- Storing opinions regarding a plan
- Alternatives
- Running simulations

Interoperability

- All domains
- Connecting two different GIS
- Problems
  - Syntactic levels
  - Semantic levels
- Track: ontologies and mediators

Web GIS

- All domains
- Distributing geoinformation via Internet
- Internet mapping / Web GIS
- Client-server of 3-tier structures
- On-demand mapping
- Track: based on XML extensions

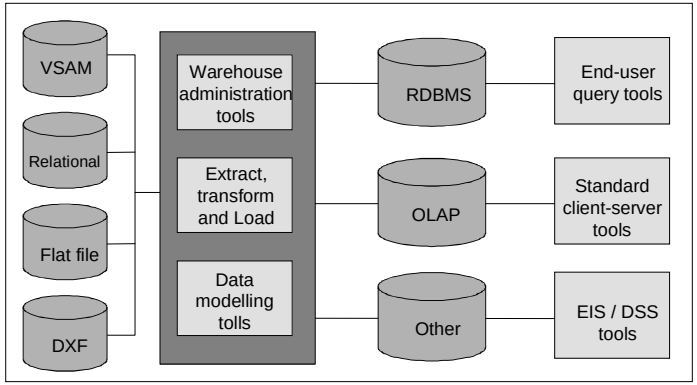
II – Current research directions in GIS Databases functionalities

- Spatio-temporal data warehousing and data mining - chorems
- XML and alikes
- 3D DBMS CityGML
- Real time GIS
- Data quality
- Ontology-based interoperability
- Location-Based Services (LBS)

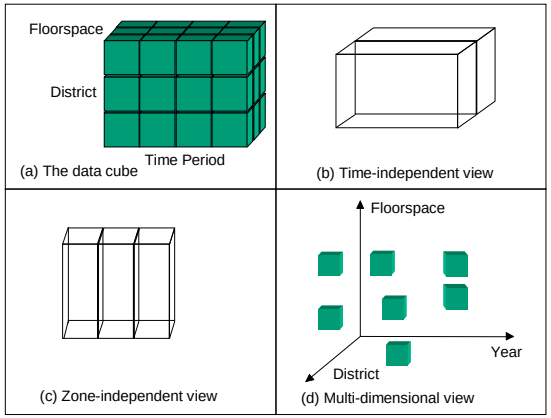
1 – Datawarehousing and Datamining

- Existing sets of geodata
- Datawarehousing
  - Making all data accessible
- Datamining
  - Finding new patterns

Datawarehouses



Datacubes



Spatial Data Mining

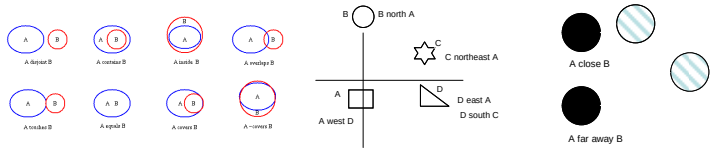
- Spatial Data Mining.
  - Discovery of implicit and previously unknown knowledge in spatial databases.
  - Knowledge discovered.
  - Types of data.

Spatial Data Mining Approaches

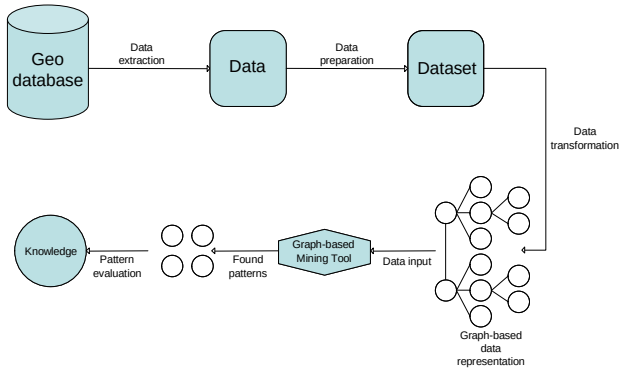
- Generalization.
  - Concept hierarchies.
- Clustering.
  - The process of grouping physical or abstract objects into classes of similar objects.
  - Approaches: Partitioning, Hierarchical, Locality-based, Grid-based.
- Spatial Associations.
  - Rules which describe the implication of one or set of features by another set of features in spatial databases.

Spatial Relations

- Topological
  - object A disjoint object B
- Direction (cardinal)
  - object B north object A
- Distance
  - object A close to object B



Spatial Data Mining Model

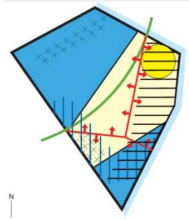


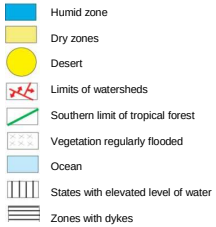
What are Chorems?

- Invented by Pr. Roger BRUNET (University of Montpellier)

- Schematized representation of a territory

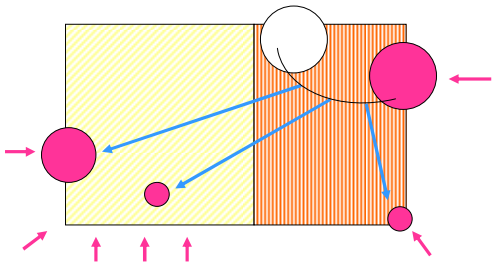
Water problem in Brazil





Conventional map	Chorem map	Caption

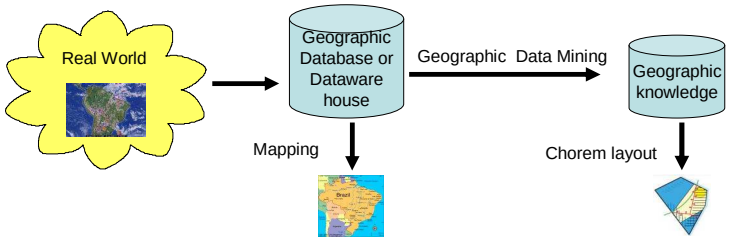
Guess!



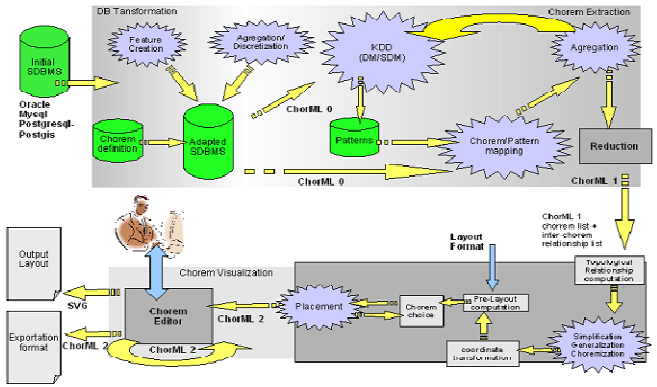
Data summaries

- Generally, generation of a text emphasizing the database objectives, structure and contents
- For geographic database, why a textual summary?
- Objective: visual summary obtained by spatial data mining

Automatic Chorem Discovery and Layout



Architecture



Geographic Data Mining (1/2)

- Lots of techniques have been developed
- Find a combination of techniques suited for geographic pattern discovery
- Differences between
  - Spatial data mining
    - Patterns which are “true” everywhere
    - *If lake + road to the lake ➔ restaurant*
  - Geographic data mining
    - Positioned patterns (spatial patterns with toponyms)
    - *Eastern coast of Spain is touristically saturated*

Geographic Data Mining (2/2)

- Starting from a geographic database
- Limited list of geographic patterns
  - Maybe 7 ± 2
- How to define the more important patterns?
  - Suppose you’ve found 10 000 geographic patterns: how to select 7 ± 2
- Encoding geographic patterns
  - XML, GML, KML, etc..

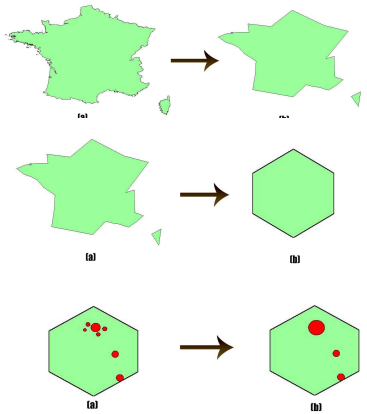
Chorem Layout

- Defining a library of elementary patterns (vector format)
- Defining rules for pattern placement
  - similarities with name placement
  - similarities with geographic generalization

Spatial Database Summaries

- Geographic generalization applied to geometric shapes
- Semantic generalization applied to non-spatial contents

Geographic and Semantic Generalization



2 – XML

- XML = Extensible Markup Language
- Generalization of HTML distinguishing contents and presentation
- Example:
  - <parcel>
  - <parcel_number> 457 LM 89 </parcel_number>
  - . . . .
  - </parcel>

XML and geodata

- SVG
  - Scalable Vector Graphics (SVG)
  - Only 2D data
  - Animation is possible
- GML
  - Geographic Markup Language
  - OpenGIS
- LandXML
  - Cadasters, engineering and land surveys works
- CityGML
  - City-wide 3D models
- KML
  - Applications based on Google Earth

3 – CityGML

- CityGML is a common information model for the representation of 3D urban objects.
- Urban objects
  - geometrical,
  - topological,
  - semantic, and
  - appearance properties..
- CityGML is implemented as an XML application schema for the Geography Markup Language 3 (GML3).

Main features of CityGML

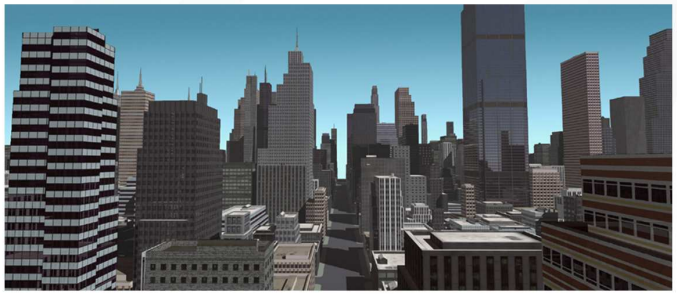
- Geospatial information model for urban landscapes based on the ISO 191xx family
- GML3 representation of 3D Geometries, based on the ISO 19107 model
- Texture and material representation of object surfaces

Urban objects

- Human artifacts (buildings, roads, etc.)
- Digital Terrain Models as a combination of triangulated irregular networks (TINs), regular rasters, break and skeleton lines, mass points
- Vegetation (areas, volumes, and solitary objects with vegetation classification)
- Water bodies (volumes, surfaces)
- Transportation facilities (both graph structures and 3D surface data)
- City furniture
- Etc.

Reconstruction of Pompei (ETH – Zurich)

A modern city (ETH – Zurich)



Californian suburbs (ETH Zurich)

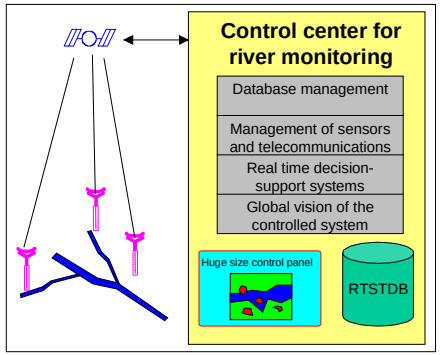
Levels of details

- Multiscale model with 5 well-defined consecutive Levels of Detail (LOD):
  - LOD 0: Regional, landscape
  - LOD 1: City, region
  - LOD 2: City districts, projects
  - LOD 3: Architectural models (out-side), landmarks
  - LOD 4: Architectural models (interior)
- Multiple representations in different LODs simultaneously; generalization relations

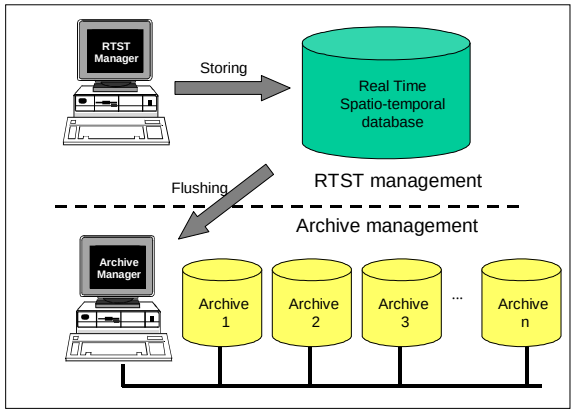
4 – Real time GIS

- Sensor-based systems
- Critical temporal constraints to follow
- Data structures more efficient for newer data than for older data
- Robustness
- Real time animated cartography

Real time DBMS structure



RTGIS structure



5 – Geographic data quality

- Lineage
- Accuracy
- Resolution
- Feature completeness
- Timeliness
- Consistency
- Quality of metadata

} Can be done or checked at DB level

Data quality checking

- Checking
  - declarative
  - procedural
  - event-driven (triggers)
- When
  - At creation
  - At each update
  - When necessary by launching procedures

Quality visualization

- Spatialized indicators
- Visualization of data quality
- Maps with quality levels

Correction

- Powerful procedures of correction
- Updating

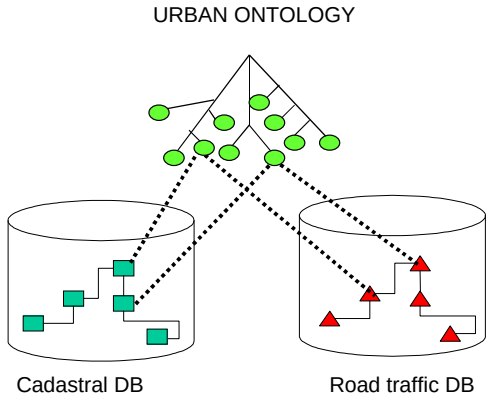
6 – Ontology-based Interoperability

- Discrepancies in data modelling
- Syntactic level
  - Data structures
  - OpenGIS
- Semantic level
  - Discrepancies in representations
  - Linguistic problems
  - Ontology

What is an ontology?

- A semantic network
- A formal description of a vocabulary
- According to Gruniger et al., ontologies can provide the following:
  - Communication between humans and machines,
  - Structuring and organizing the virtual libraries, and the receptacles of the plans,
  - Reasoning by inference, particularly in very large databases

Ontology



Towntology Project

- Creating an ontology for urban planning
- First steps in Lyon (2002-2003)
  - Street planning (French language)
  - ≅ 800 concepts
- Second step (2003-2004)
  - Setting a COST network
  - Extension to other languages
  - Public space description

Towntology principles

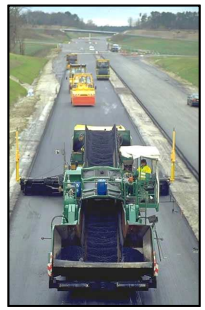
- Visual presentation
- Semantic network
- Hypertext structure
- Multiple definitions
- Origin and lineage of definitions
- Possibility of updating
- Photos and drawings

- ➔ Pre-consensus ontology: so to determine concept's definitions

MIX
Aggregates gravel, sand...) of variable size, mixedwith lime and closely bound by a called bitumen binder bituminizes. The bituminous mix is used mainly in carriageway surfacing. One distinguishes two main categories of bituminous mix :
• Hot-mix, used in courses and underlayers of coating in the structures of roadway. These products are implemented and compacted at a temperature varying between 135 and 160°C.
• Cold-mix generally used to stop the "potholes" or provisional repair of the trenches.

Roadway dictionnary

From : http://www.lequotidienauto.com



Example of textual and visual description

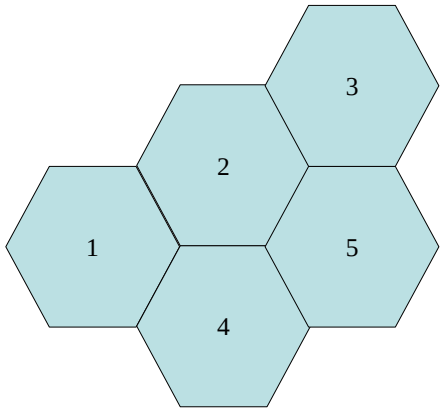
7 – LBS

- Mobile queries and transactions
- Mobile query = query whose answer depends on querier's location
- Examples:
  - where is the next restaurant?
  - where are the next gas stations?

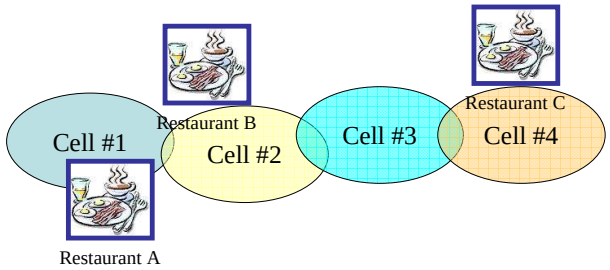
Automatic adaptation

- Location
  - Categories
  - Service discovery
- User profile
  - Language, interest
  - Requirements
  - Profile modification (ex. doctor)
- Hardware

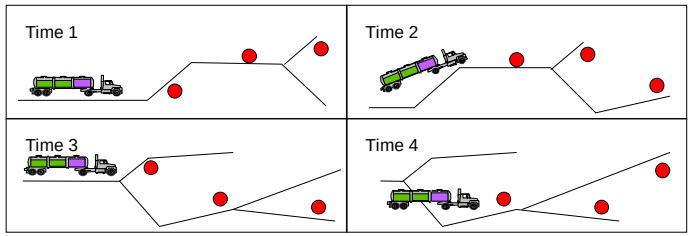
Cellular organization



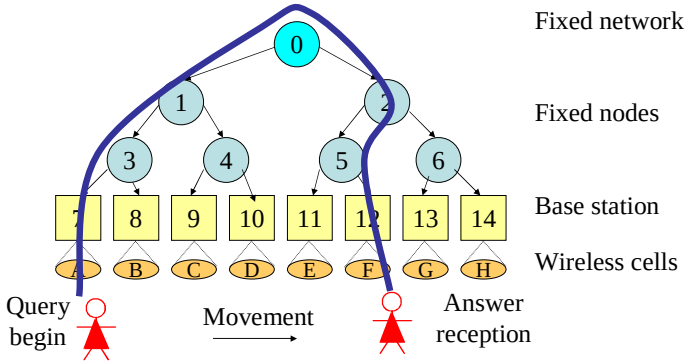
Cells and services



Query: "*what are the five nearest gas stations?*"



Path for mobile queries and answers



Problems

- Data infrastructure
- Location
- Indexing
- Cache
- Privacy

III – New Earth-wide projects

- New projects covering the whole earth:
  - New developments of Google Earth
  - Microsoft « Virtual Earth »
- Global vision and local search
- Huge integration of data coming from different sources
- Framework for more…

Google

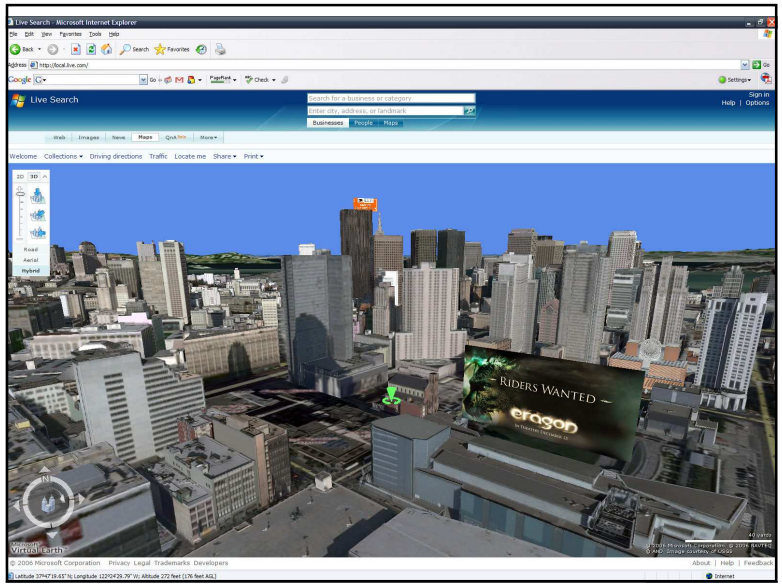
- *« Organize the world's information and make it universally accesiible and useful »*
- Keyhole ➔ Google

- A worldwide infrastructure for organizing information
- Google book search: places mentioned in books

Google Maps/Earth

- http://maps.google.com/help/maps/streetview/index.html
- http://www.youtube.com/watch?v=MGfozDZDSI8
- http://www.youtube.com/watch?v=fHkXYaRP0ls

- http://video.google.com/videoplay?docid=-3097896187368461444&q=%22google+earth%22&total=11996&start=0&num=10&so=0&type=search&plindex=3



Microsoft

- *« Mind-expanding »*
- Vexcel ➔ Microsoft

- A worldwide infrastructure for geo-referenced applications

- Orthorectified aerial photos (pixel=15cm)
- Bird-eye views
- Bare earth topography
- 2.5 D textured buildings
- Handheld augmented reality

Microsoft

- Virtual Earth:
  - http://maps.live.com/
  - http://www.metacafe.com/fplayer/496241/flying_in_virtual_earth.swf

Comparison

- http://www.metacafe.com/watch/496217/google_and_virtual_earth_city_by_city/

IV – Final remarks

- New functionalities of GIS database
  - mobility - LBS
  - 3D
  - real time
  - quality
  - web
  - interoperability
  - Summarizing
  - *Oracle 10g is not enough..*
  - etc

Thanks for your attention!

http://liris.insa-lyon.fr/robert.laurini