Université de Liège

Unit of Geomatics

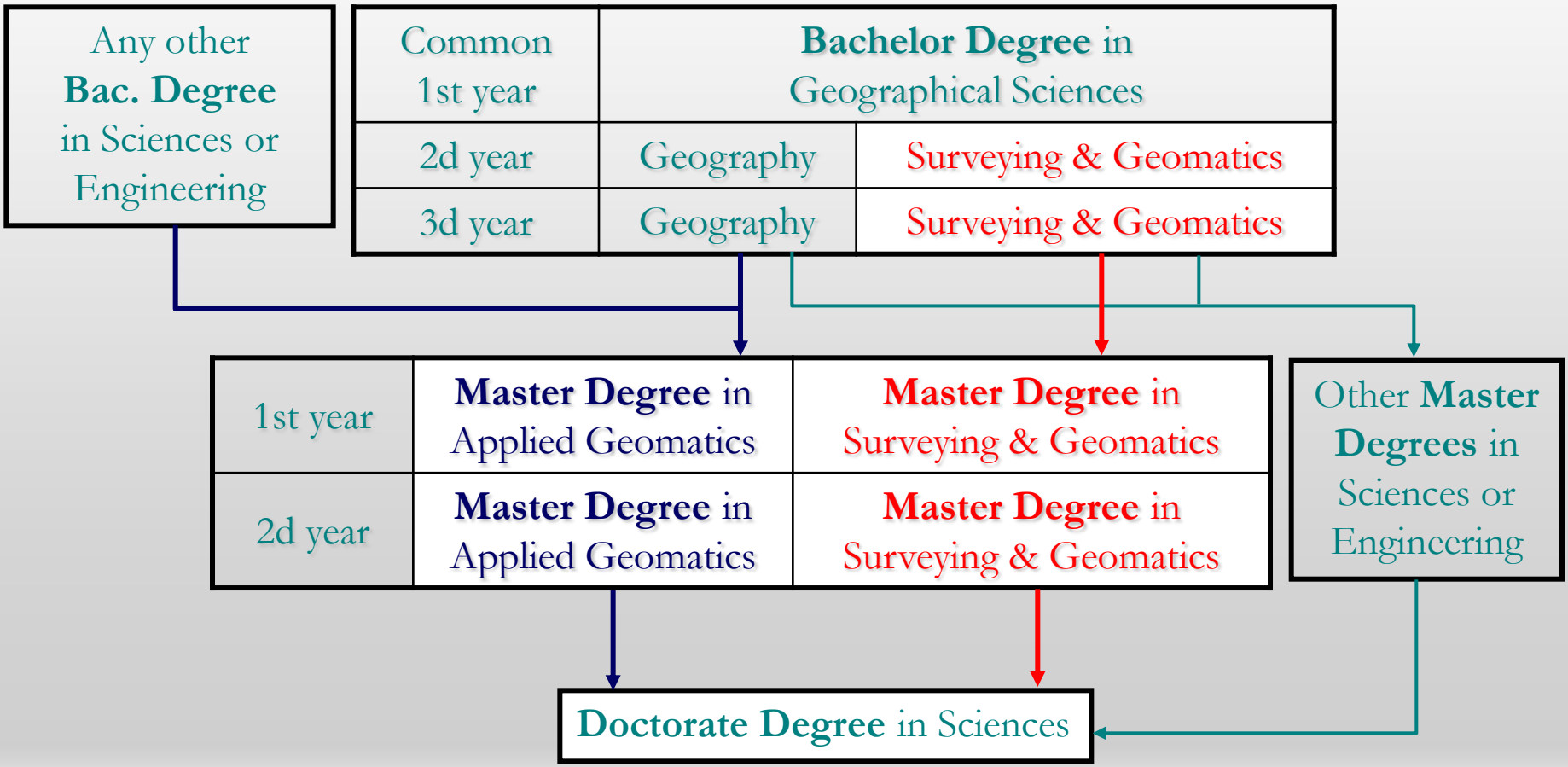
Qualitative Spatio-Temporal Reasoning & Spatial Database Design

Focus on 2 research topics
at the Unit of Geomatics
of the University of Liège

J-P. Donnay – P. Hallot – F. Laplanche

Curriculum in « Surveying & Geomatics » in the Faculty of Sciences of the University of Liège

Only education programme devoted to this field in the French-speaking Belgian Universities !



International Education Networks

Master Degree in Applied Geomatics

- Sherbrooke
- Montpellier

Master Degree in Surveying & Geomatics

- Laval
- Paris – Le Mans - Strasbourg

EEGECS

The Unit of Geomatics

Chairs and shared research domains

Geodesy	**Photogrammetry**	**Topography**	**Remote Sensing**	**Cartography**
GNSS			**Spatial Analysis**	
		GIS		

Staff

Professors: 5
Prof. Assistant (Dr): 1
Researchers - Assistants (PhD Students): 7
Researchers: 5
Tech/Admin: 2

Typical applied researches

- **Federal & Regional Agencies**
  - **GIS design & reengineering**
    - **See Poster 1**
      Distributed GISystem based on network technology
  - **RTK GPS network assessment**
  - **« Crime mapping » & « Geographic profiling »**
- **Academic subcontracting, Local Authorities & Private Companies**
  - **Web GIS development**
  - **Maps and Atlas design and production**
- **International projects**
  - **Geodesy & mathematical cartography (border conflicts)**
  - **GIS & SDI design**

Examples of fundamental research topics

- **GNSS**
  - **See poster 2**
    Ionosphere Modelling for GALILEO Single-Frequency Users
- **Satellite photogrammetry**
  - **See poster 3**
    DTM extraction and validation from SPOT 5 satellite imagery
- **Qualitative spatial reasoning**
  - **Spatio-temporal reasoning: Lecture 1**
- **GIS design**
  - **Open Source Spatial Database Design: Lecture 2**

Université de Liège

Unit of Geomatics

Qualitative Spatio-Temporal Reasoning

Research on a generalized
spatio-temporal reasoning model

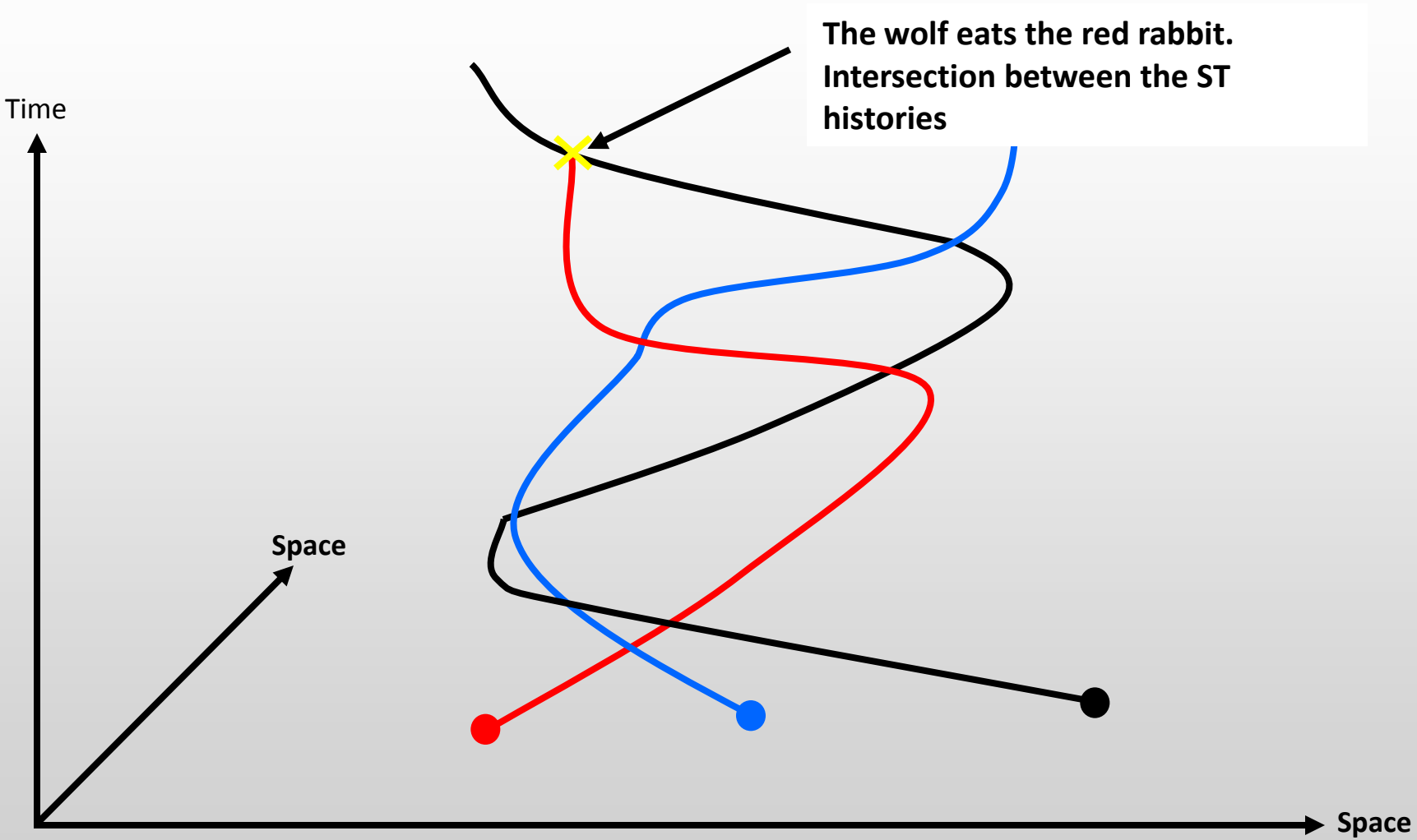
J-P. Donnay – P. Hallot – F. Laplanche

Outlines

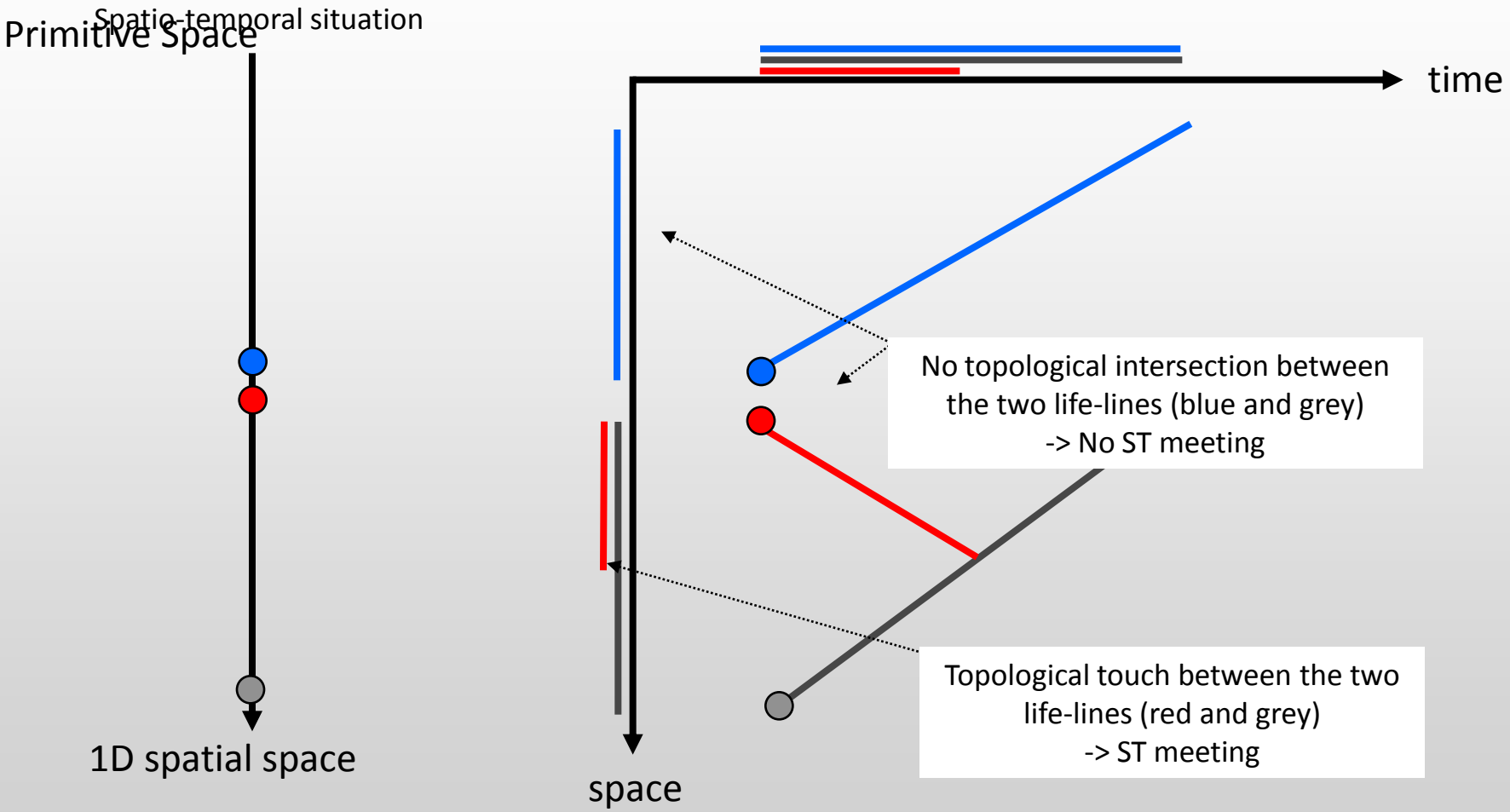
- Introduction
- Life-lines representation
- Research objectives
- Spatial "states"
- Spatio-temporal configurations

Qualitative spatio-temporal reasoning

- Growth of **dynamics data acquisition systems** (on-board GPS, RFID-tags, Wi-Fi,…)
- Huge quantity of **spatio-temporal data**
- Necessity to develop **spatio-temporal reasoning model** to **extract information**
- Several ways to develop spatio-temporal reasoning model :
  - **Combining a spatial and a temporal logic**
  - **Create a mereotopology from the analysis of spatio-temporal histories**
- Users expects **simple** systems, useful and easily integrated


The wolf eats the red rabbit.
Intersection between the ST histories
Time
Space
Space

Moving points in a 1D space

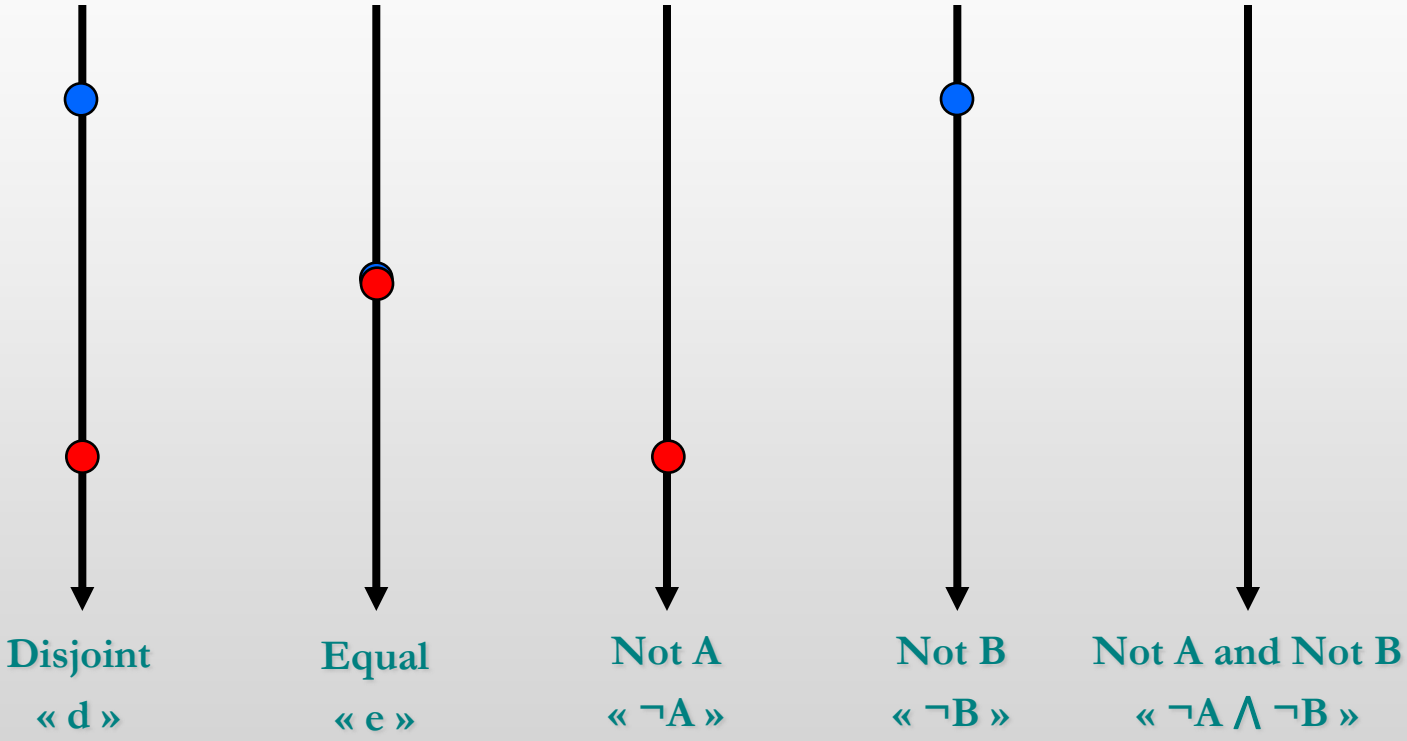


General research objectives

- The underlying idea of this research is to **extract spatio-temporal information by applying topological calculi on the life-lines.**

- Research's steps of PhD :
  - **Construct an exhaustive set of ST configurations mixing topological relationships and Allen's time intervals.**
  - Develop a ST model based on topological calculi.
  - Study the relevance of such a model / generalisation.

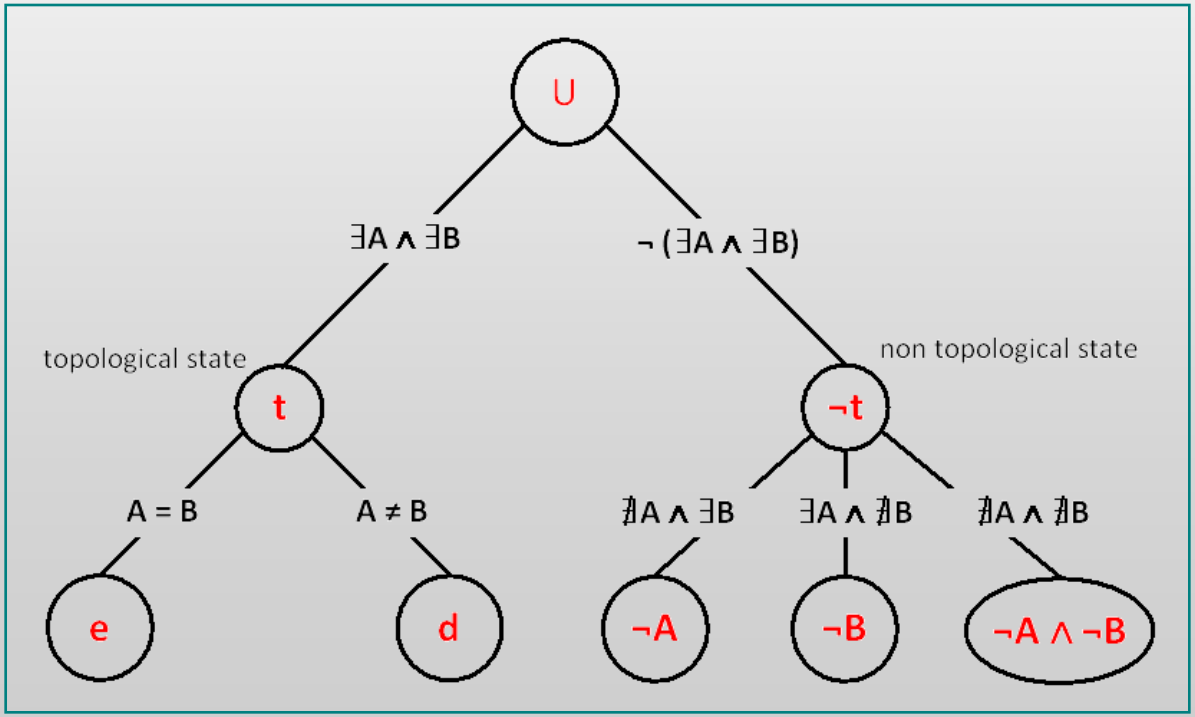
Degenerated topological relationships



To fully encompass the ST information complexity, we propose 3 degenerated topological relationships between points.

Degenerated topological relationships

- A « state » is a particular relationships between objects at a given time.
- JEPD set of relationships:



e e d e ¬A

	B°	δB	B-
A°	1	0	1
δA	1	1	0
A-	1	1	1

e e d e ¬B

	B°	δB	B-
A°	1	1	1
δA	0	1	1
A-	1	0	1

¬A e d e ¬A

	B°	δB	B-
A°	0	0	1
δA	1	0	0
A-	1	1	1

¬A e d e ¬B

	B°	δB	B-
A°	0	1	1
δA	1	0	1
A-	1	1	1

¬B e d e ¬B

	B°	δB	B-
A°	0	1	1
δA	0	0	1
A-	1	0	1

¬A e e d e ¬A

	B°	δB	B-
A°	1	0	1
δA	1	0	0
A-	1	1	1

¬B e e d e ¬B

	B°	δB	B-
A°	1	1	1
δA	0	0	1
A-	1	0	1

e e d e

	B°	δB	B-
A°	1	0	1
δA	0	1	0
A-	1	0	1

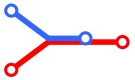
e d e ¬A

	B°	δB	B-
A°	0	0	1
δA	1	0	1
A-	1	1	1

e d e ¬B

	B°	δB	B-
A°	0	1	1
δA	1	0	1
A-	1	0	1

d e e ¬A



	B°	δB	B-
A°	1	0	1
δA	1	0	1
A-	1	1	1

d e e ¬B

	B°	δB	B-
A°	1	1	1
δA	1	0	1
A-	1	1	1

¬A e e ¬A

	B°	δB	B-
A°	1	0	0
δA	1	0	1
A-	1	1	1

¬A e e ¬B

	B°	δB	B-
A°	1	1	1
δA	0	0	1
A-	1	1	1

¬B e e ¬B

	B°	δB	B-
A°	1	1	1
δA	0	0	1
A-	0	0	1

33 Topological relationships between lines

e e

	B°	δB	B-
A°	1	0	0
δA	0	1	0
A-	0	0	1

e d

	B°	δB	B-
A°	0	0	1
δA	0	1	1
A-	1	1	1

d d

	B°	δB	B-
A°	0	0	1
δA	0	0	1
A-	1	1	1

e e d

	B°	δB	B-
A°	1	0	1
δA	0	1	1
A-	1	1	1

e e ¬A

	B°	δB	B-
A°	1	0	0
δA	1	1	0
A-	1	1	1

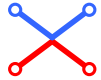
e e ¬B

	B°	δB	B-
A°	1	1	1
δA	0	1	1
A-	0	0	1

e d e

	B°	δB	B-
A°	0	0	1
δA	0	1	0
A-	1	0	1

d e d



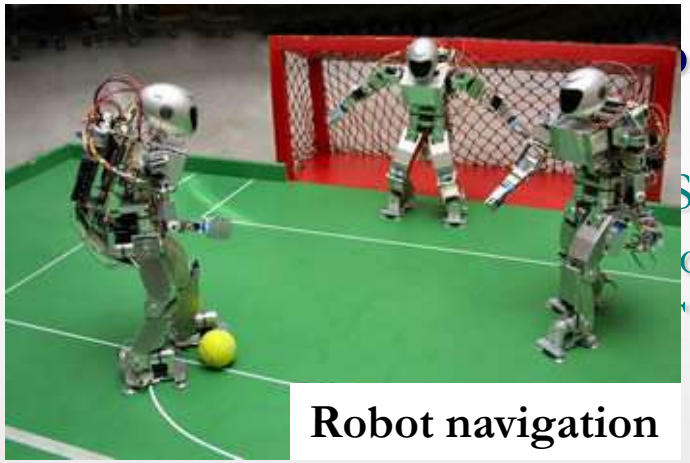
	B°	δB	B-
A°	1	0	1
δA	0	0	1
A-	1	1	1

d e ¬A

	B°	δB	B-
A°	0	0	1
δA	1	0	1
A-	1	1	1

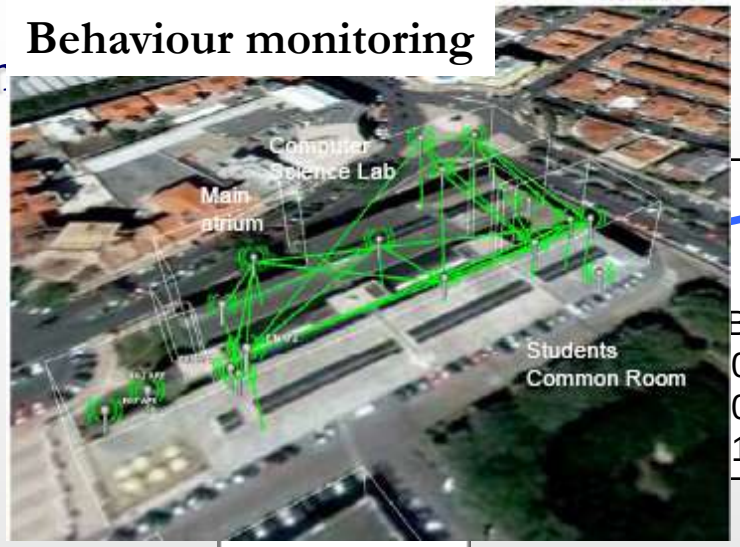
d e ¬B

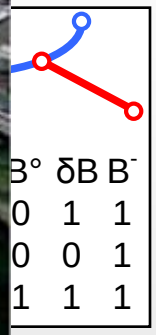
	B°	δB	B-
A°	0	1	1
δA	0	0	1
A-	1	1	1



Robot navigation

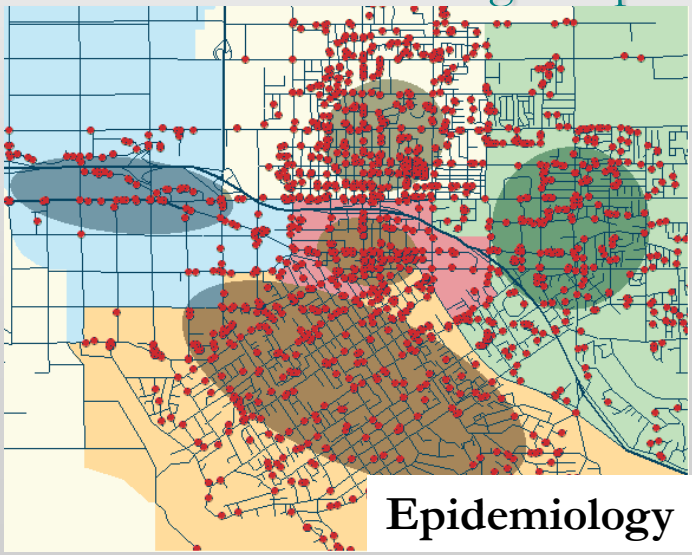
Behaviour monitoring





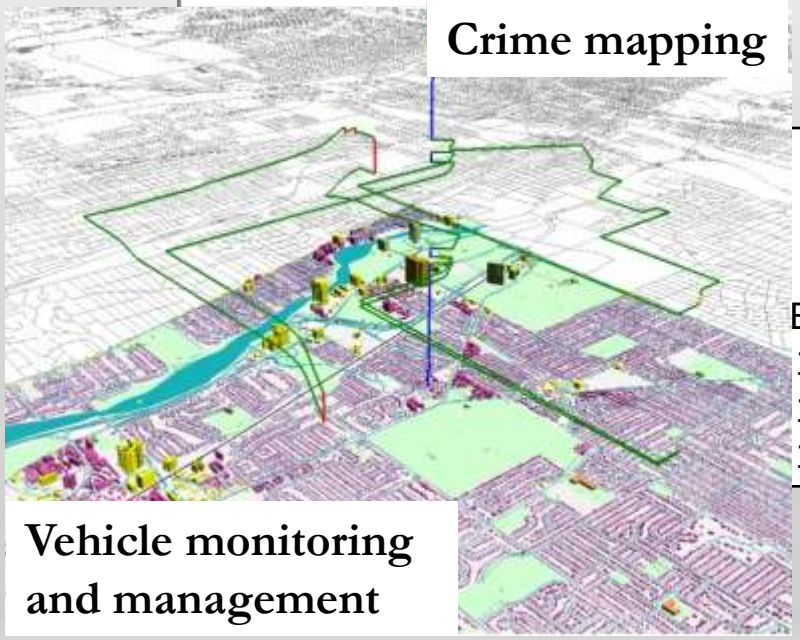
B°	δB	B⁻
0	1	1
0	0	1
1	1	1

- Extend model to higher spatial



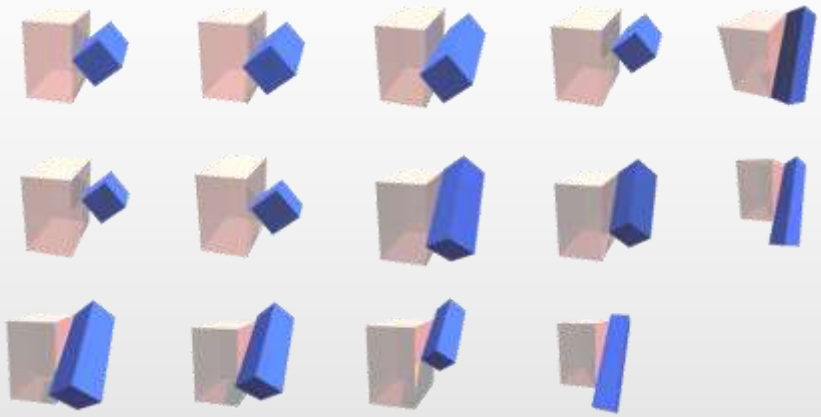
Epidemiology

Crime mapping



Vehicle monitoring and management

Qualitative spatial reasoning

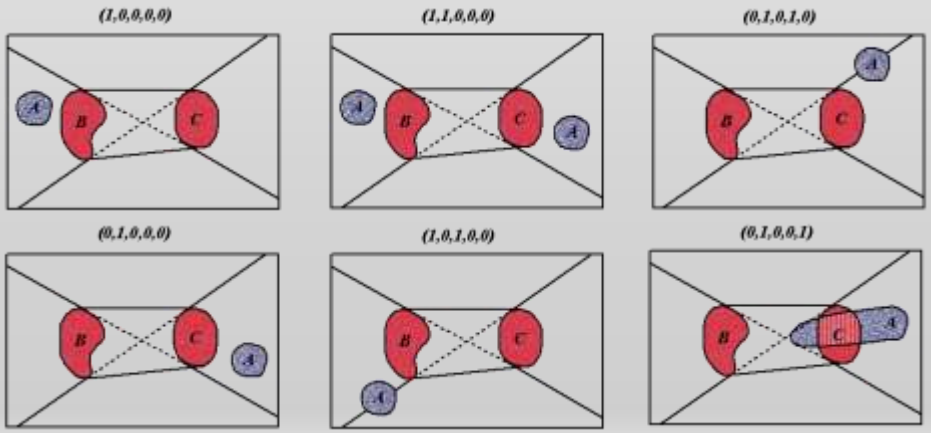


Binary projective relationships model

Billen R., Zlatanova S., Mathonet P. & Boniver F. 2002. The Dimensional Model: a framework to distinguish spatial relationships.
in D.Richardson & P. Van Oosterom (Ed.), *Advances in Spatial Data Handling*. Berlin Heidelberg, Springer-Verlag, pp. 285-298.

Ternary projective relationships model

Clementini E. & Billen R. 2006. Modeling and Computing Ternary Projective Relations Between Regions, *IEEE Transactions on Knowledge and Data Engineering*, 18 (6), pp. 799-814.



Université de Liège

Unit of Geomatics

Spatial Database Design

Web2GIS: a spatial database conception environment

J-P. Donnay – P. Hallot – F. Laplanche

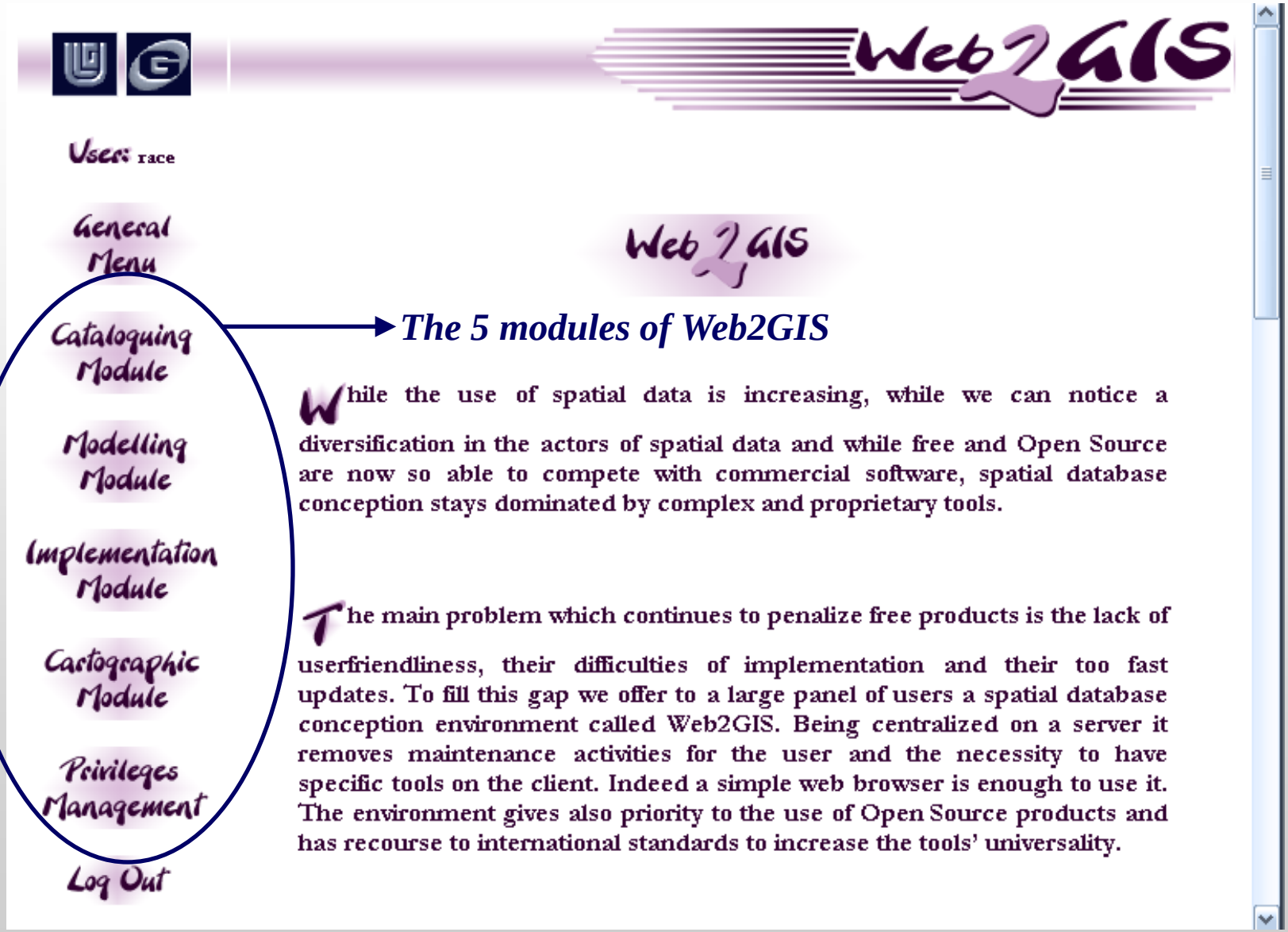
Web2GIS

- **Realized in the framework of a PhD defended on September 8th 2006**
- **Assessment:**
  - **Integrated tools for Spatial Databases conception stay essentially proprietary**
    - **High cost**
    - **Lack of standardization**

  → **Solution : Using Open Source software implementing well-known standards**
- **Some problems still penalize Open Source solutions:**
  - **Maintenance and compatibility problems due to fast update**
  - **Lack of user-friendly interfaces**
  - **Lack of technical support**

Web2GIS

- **Our original solution: Web2GIS**
  - Spatial database conception environment centralized on a web server
    - No need of particular tools on client, just a web browser
  - Adapted to a large panel of users
    - Spatial data producers, spatial database designers, spatial data users…
  - Giving priority to Open Source products and international standards
    - Apache, Php, PostGIS, MapServer…
    - ISO/TC 211 (19 1..), OGC…
  - In the philosophy of WEB 2.0
    - *« Web 2.0 is the business revolution in the computer industry caused by the move to the internet as platform… »*


Web2GIS
User: race
General Menu
Cataloguing Module
Modelling Module
Implementation Module
Cartographic Module
Privileges Management
Log Out
Web2GIS
The 5 modules of Web2GIS
While the use of spatial data is increasing, while we can notice a diversification in the actors of spatial data and while free and Open Source are now so able to compete with commercial software, spatial database conception stays dominated by complex and proprietary tools.
The main problem which continues to penalize free products is the lack of userfriendliness, their difficulties of implementation and their too fast updates. To fill this gap we offer to a large panel of users a spatial database conception environment called Web2GIS. Being centralized on a server it removes maintenance activities for the user and the necessity to have specific tools on the client. Indeed a simple web browser is enough to use it. The environment gives also priority to the use of Open Source products and has recourse to international standards to increase the tools' universality.

Web2GIS – Feature Cataloguing Module

- **Goal:**
  - Generate Feature Catalogues for data producer communities whishing to describe their specifications
- **ISO/TC 211 – 19110 : Methodology for feature cataloguing**
  - Metabase model is inherited from the norm
- **More important purpose than just a textual description**
  - Reflection on the concept of object
  - UML design of associations
    - Reflection on the concept of cardinality
    - Possibility to reuse associations during conceptual modelling

Current Catalogue: Carteco_Catalogue v1

Web2GIS

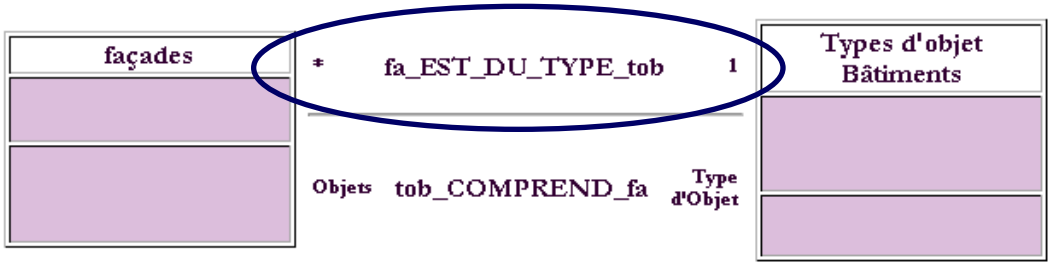
Visualization...	Modification...	Addition...	Deletion...
Visualization...	Modification...	Addition...	Deletion...
Show all feature types	Modify a feature type	Add a feature type	Delete a feature type
Show a feature type	Modify an attribute / operation	Add an attribute / operation	Delete an attribute / operation
	Modify an attribute value	Add an attribute value	Delete an attribute value
	Modify a feature association	Add a feature association	Delete a feature association
	Modify a constraint	Add a constraint	Delete a constraint

Version Number	1
Version Date	2005-08-02
Scope	- Données Topographiques des éléments du domaine public satisfaisant les exigences les plus grandes en termes de précision et complétude
Field of Application	- Préalable à la reconceptualisation de la BD Carteco
Definition Source	- Catalogue des objets de la BD Carteco
Definition Type	-
Producer	François Laplanche
Functional Language	

Feature Association

Code	ASSOC006
Name	fa_EST_DU_TYPE_tob
Inverse Relationship	tob_COMPREND_fa
Definition	Les façades sont du type d'objet Bâtiments
Order Indicator	Yes
Constraints	

UML Notation:



Feature Type

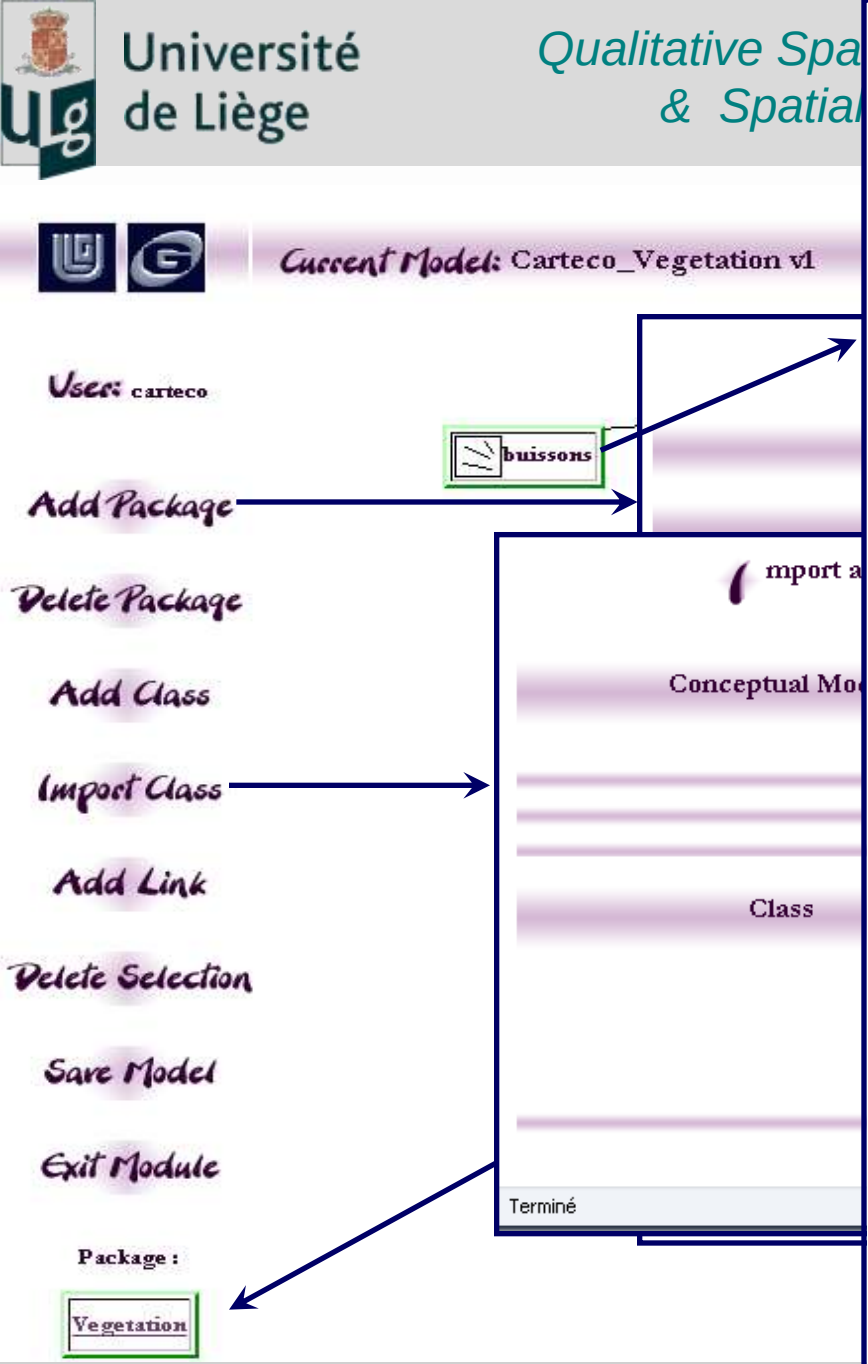
	BB01
	façades
	pour tous les bâtiments, on portera sur la carte les façades principale et latérales effectives jusqu'à 5 mètres ou jusqu'au premier point adéquat.

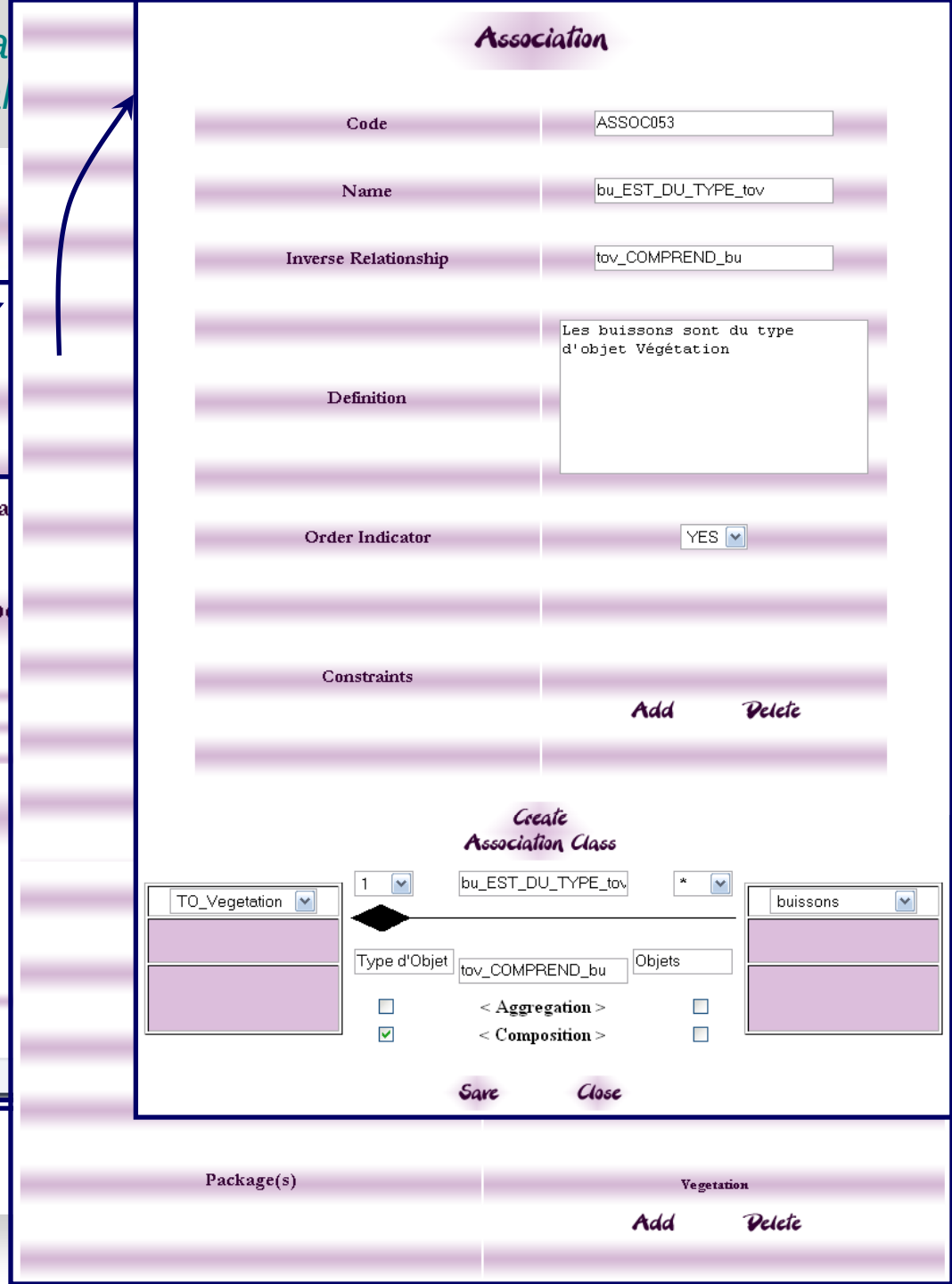
fa_EST_DU_TYPE_tob

Previous Next > Last >>

Web2GIS – Conceptual Modelling Module

- **Goal:**
  - Offering to the user a conceptual data model generator enabling to deal with specific applications from scratch or from one or several Feature Catalogues
- **UML has been chosen as formalism**
  - It's based on a metamodel expressed in UML
  - UML can be extended
- **Metabase model is based on UML metamodel and spatio-temporal extensions**
  - ISO 19109 (Rules for application schema) and 19107 (Spatial schema)
  - Topological constraints based on (enriched) CONGOO concepts


Current Model: Carteco_Vegetation v1
User: carteco
buissons
Add Package
Delete Package
Add Class
Import Class
Add Link
Delete Selection
Save Model
Exit Module
Package :
Vegetation
mport a
Conceptual Mo
Class
Terminé


Association
Code
ASSOC053
Name
bu_EST_DU_TYPE_tov
Inverse Relationship
tov_COMPREND_bu
Definition
Les buissons sont du type d'objet Végétation
Order Indicator
YES
Constraints
Add
Delete
Create Association Class
TO_Vegetation
1
bu_EST_DU_TYPE_tov
*
buissons
Type d'Objet
tov_COMPREND_bu
Objets
< Aggregation >
< Composition >
Save
Close
Package(s)
Vegetation
Add
Delete

Complete the Topological Matrices of the package "Topological_area "

Classical Topological Matrix

Strong Topological Matrix

	Batiments	Parcelles	ZonesPS	Secteurs	Communes	Arrondissements
Batiments		1 +St				
Parcelles						
ZonesPS						
Secteurs						
Communes						
Arrondissements						

Enter the topological constraints stayed between "Batiments " & "Parcelles "

Cardinalities

- 0
- 0,1
- 1
- N
- 1,N
- T

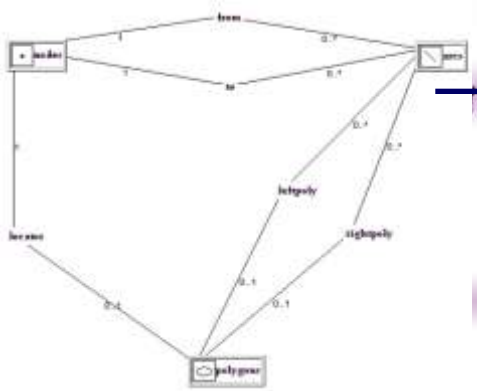
Constraints

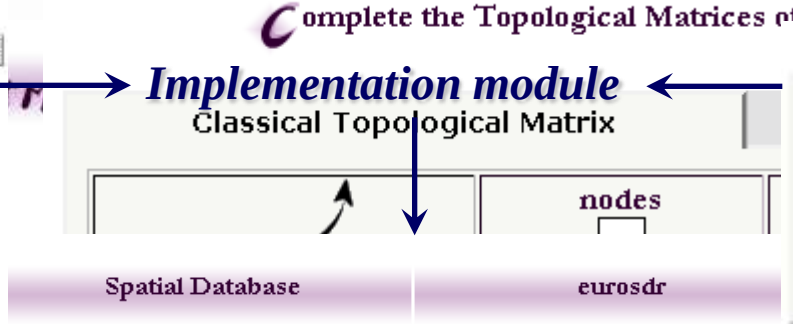
- Partial superimposition (+)
- Total superimposition (+)
- No superimposition (+)
- Partial superimposition (-)
- Total superimposition (-)
- No superimposition (-)
- Partial adjacency (+)
- Total adjacency (+)
- No adjacency (+)
- Partial adjacency (-)
- Total adjacency (-)
- No adjacency (-)

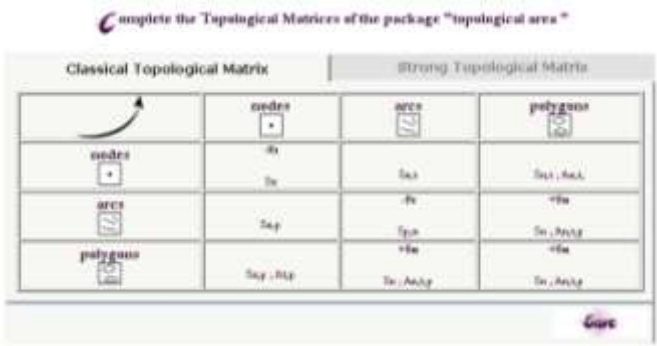
Apply Close

Web2GIS – Spatial Databases Implementation module

- **Goal:**
  - Allowing to generate the schema of a spatial database from one or several UML models and to load data into the tables of this database
- **The « Case tool » part of Web2GIS**
  - Automatic generation of spatial databases
- **Data Loading**
  - Spatial data:
    - Shapefiles
    - Text files (geometry column in WKT)
  - Non spatial data:
    - Text files







public.spatial_ref_sys

Field	Type	Length	Lengthvar	NotNull
srid	int4	4	-1	t
auth_name	varchar	-1	260	f
auth_srid	int4	4	-1	f
srtext	varchar	-1	2052	f
proj4text	varchar	-1	2052	f

public.geometry_columns

Field	Type	Length	Lengthvar	NotNull
f_table_catalog	varchar	-1	260	t
f_table_schema	varchar	-1	260	t
f_table_name	varchar	-1	260	t
f_geometry_column	varchar	-1	260	t
coord_dimension	int4	4	-1	t
srid	int4	4	-1	t
type	varchar	-1	34	t

public.nodes

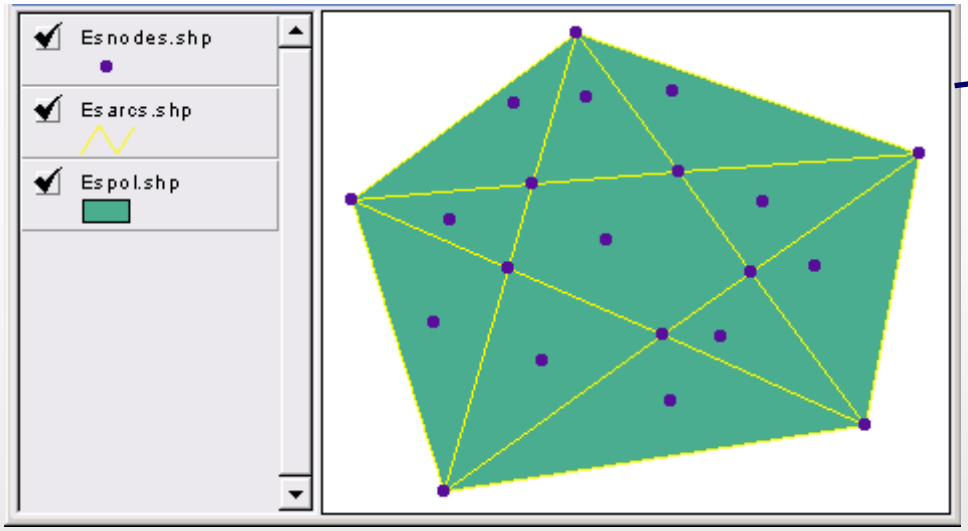
Field	Type	Length	Lengthvar	NotNull
nodes_id	int4	4	-1	t
the_geom	geometry	-1	-1	f

public.arcs

Field	Type	Length	Lengthvar	NotNull
arcs_id	int4	4	-1	t
the_geom	geometry	-1	-1	f
from_nodes_id	int4	4	-1	t
to_nodes_id	int4	4	-1	t
leftpoly_polygons_id	int4	4	-1	f
rightpoly_polygons_id	int4	4	-1	f

public.polygons

Field	Type	Length	Lengthvar	NotNull
polygons_id	int4	4	-1	t
the_geom	geometry	-1	-1	f
locator_nodes_id	int4	4	-1	t



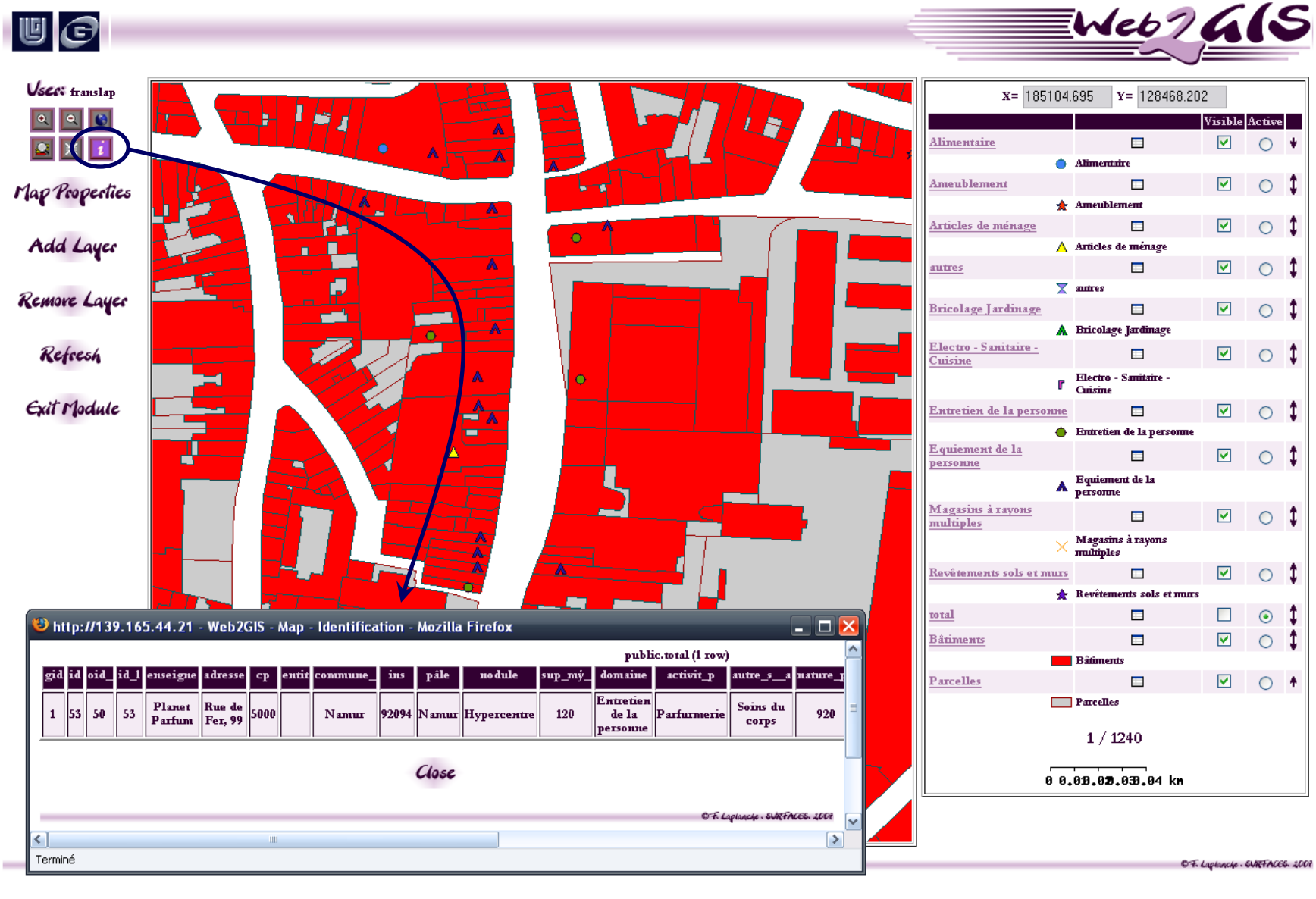
Data loading in a temporary database

Select the topological rules you want to check

	Non constrained database	Final constrained database	nodes	arcs	polygons
nodes	esnodes	public.nodes	CTM ✓ STM ○	CTM ○ STM ○	CTM ○ STM ○
arcs	esarcs	public.arcs	CTM ○ STM ○	CTM ✓ STM ○	CTM ✓ STM ○
polygons	espol	public.polygons	CTM ○ STM ✓	CTM ✓ STM ○	CTM ✓ STM ○

Check

Data loading in the final database


Web2GIS
User: franslap
Map Properties
Add Layer
Remove Layer
Refresh
Exit Module
X= 185104.695 Y= 128468.202
Visible
Active
Alimentaire
Ameublement
Articles de ménage
autres
Bricolage Jardinage
Electro - Sanitaire - Cuisine
Entretien de la personne
Equiement de la personne
Magasins à rayons multiples
Revêtements sols et murs
total
Bâtiments
Parcelles
1 / 1240
0 0.01 0.02 0.03 0.04 km
http://139.165.44.21 - Web2GIS - Map - Identification - Mozilla Firefox
public.total (1 row)
gid id oid_ id_1 enseigne adresse cp entit commune_ ins pâle nodule sup_mý_ domaine activit_p autre_s_a nature_p
1 53 50 53 Planet Parfum Rue de Fer, 99 5000 Namur 92094 Namur Hypercentre 120 Entretien de la personne Parfurmerie Soins du corps 920
Close
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Terminé

Web2GIS – Privileges Management Module

- **Goal:**
  - Allowing a project manager to manage efficiently users and privileges for protecting users developments
- **Registration needed before the first use**
  - A valid email address is needed
  - Users give a username and password
- **A user receives full privileges on his developments and may provide access to other users**
  - 3 levels of privileges
    - **Basic:** reading
    - **Large:** reading and edition
    - **All:** reading, edition, addition/deletion and privileges management

Web2GIS - Prospects

- Reports generators
  - For Feature catalogue and conceptual modelling modules
- A metadata module
  - Customization of proposed generic profiles (UML models) to generate new meta-database
  - Metadata publication and sharing of spatial data
- Dealing with the temporal dimension
  - For conceptual modelling and implementation modules
- Dealing with the third dimension and integration of works on 3D data acquisition