An Open 3D Framework for the Development of Geographic Applications

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IGN, France
COGIT, research laboratory

June 2nd – 5th 2009 Hannover, Germany

Introduction

- ✓ Why developing a 3D framework ?

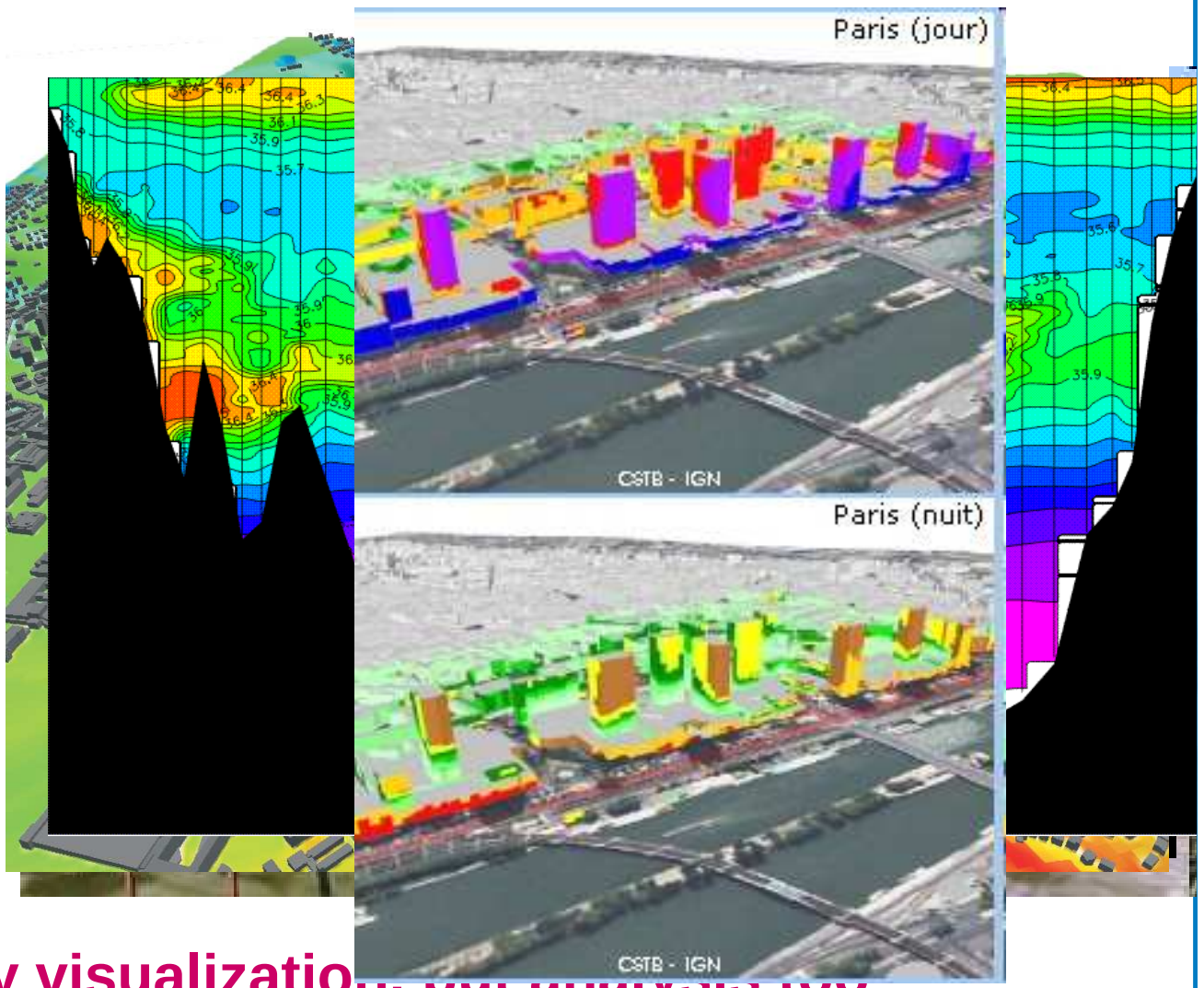
- ✓ Presentation of the framework
  - Architecture,
  - Functions

- ✓ Applications
  - Building generalization,
  - Project TerraMagna

- ✓ Conclusion

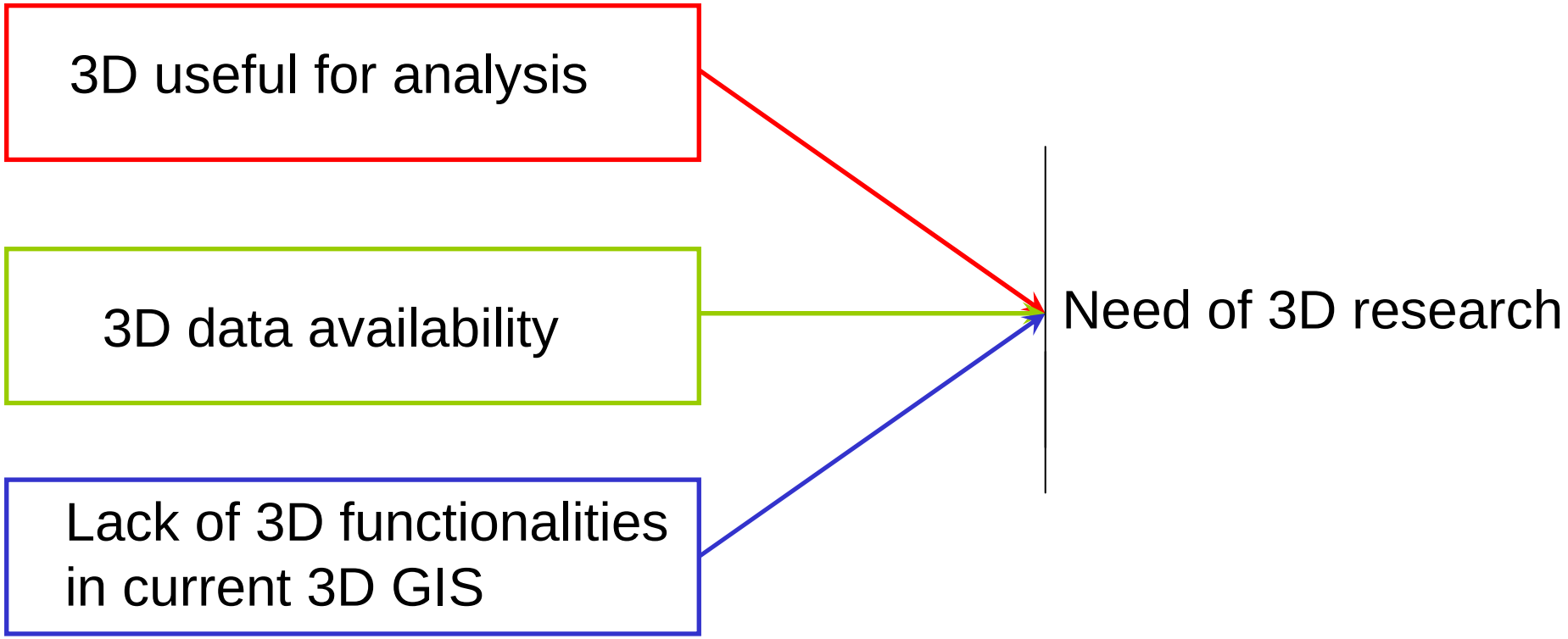
3D applications

- ✓ Land Planning
- ✓ Risk and pollution
- ✓ Network management
- ✓ Antenna implantation
- ✓ Continuous spaces



↳ **Not only visualization, but analysis too**

Why developing a 3D framework?



GEOXYGENE : Open framework for the development of interoperable applications

Project GeOxygene (http://oxygene-project.sourceforge.net/)

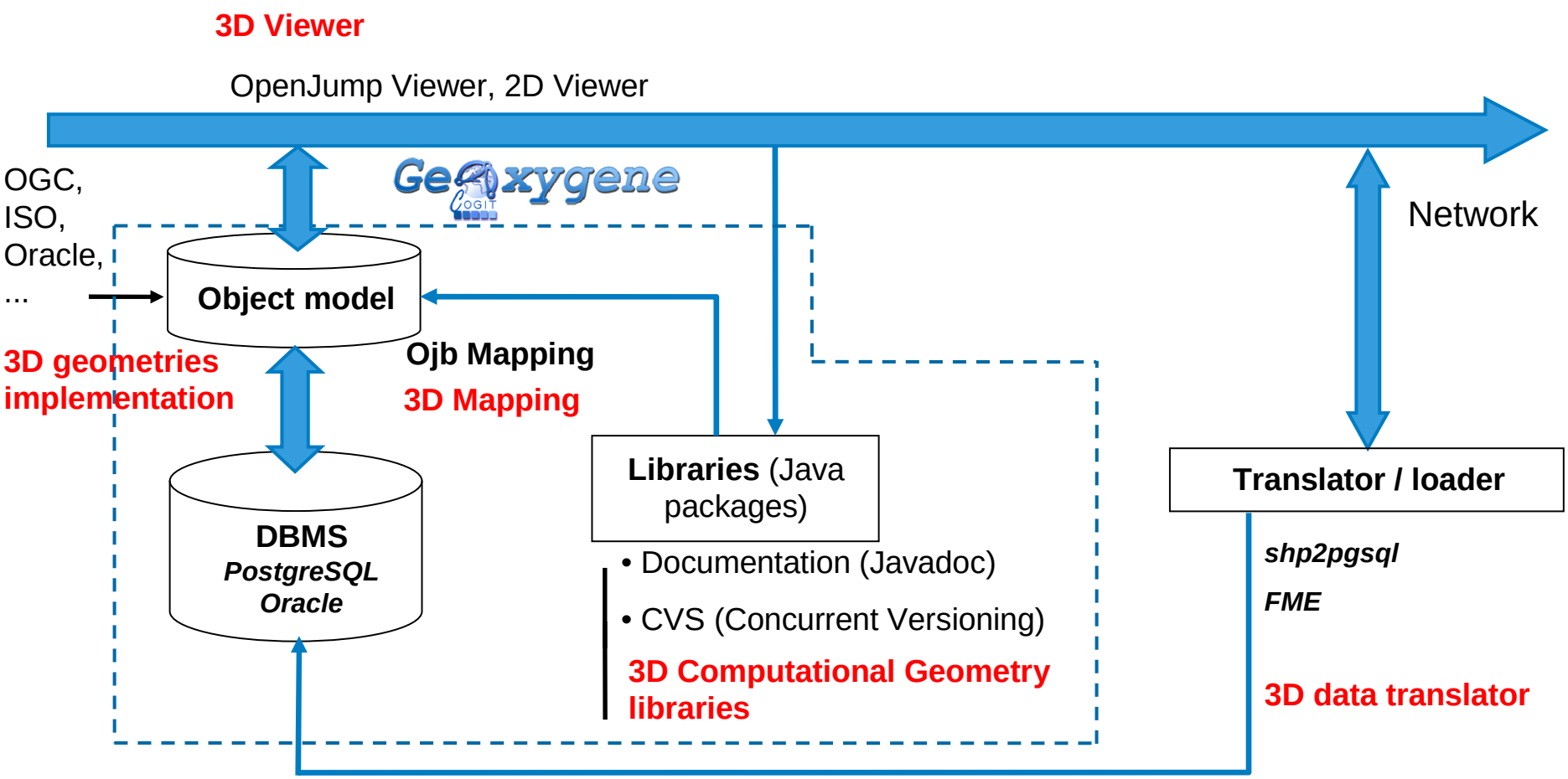
- ✓ Stemming from researches undergone at the COGIT laboratory
- ✓ Under LGPL license
- ✓ Last release : Version 1.3 on January

Features

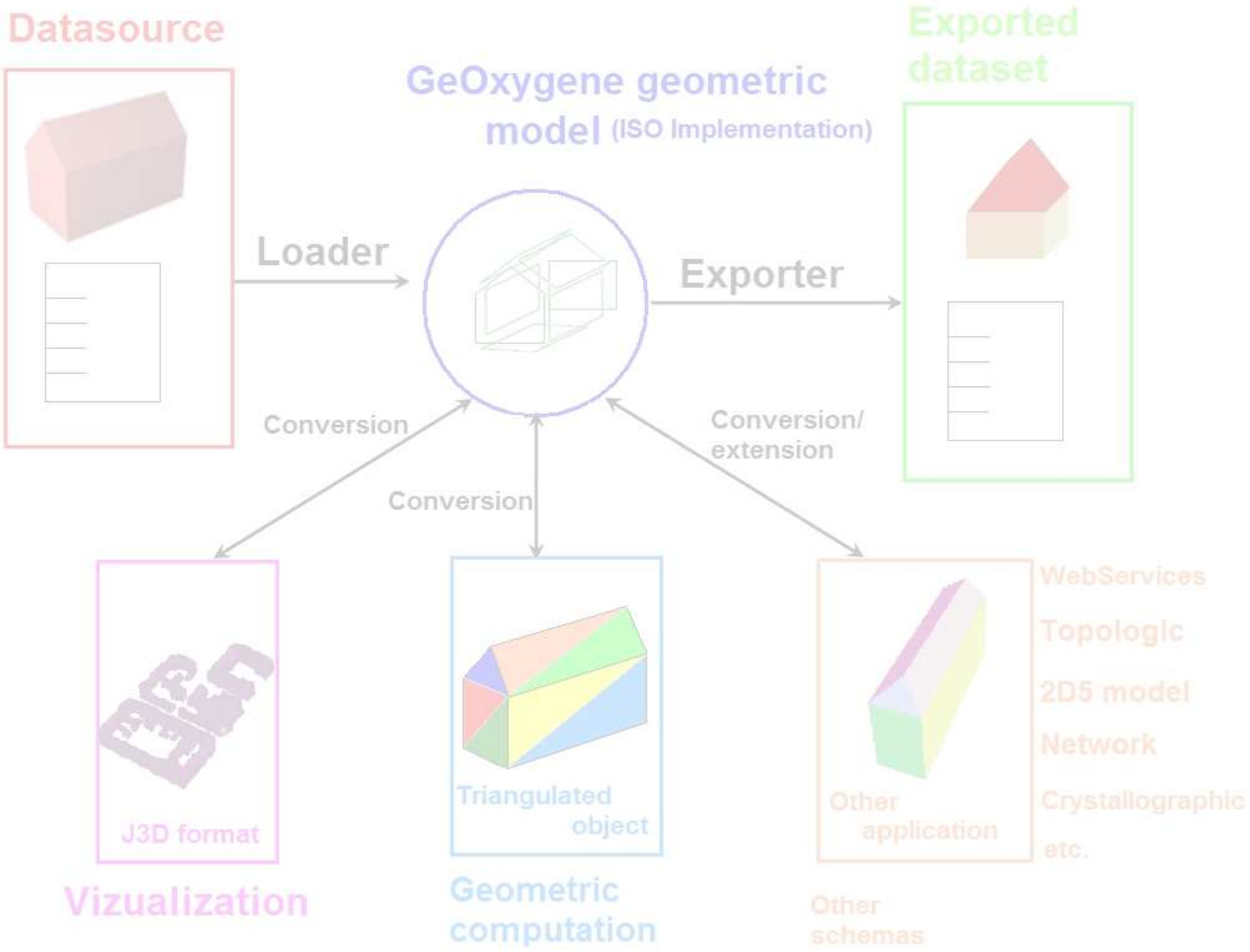
- ✓ Schema based on ISO implementation (Geometry, metadata, feature …)
- ✓ Developed in Java
- ✓ Provides PostGIS object connection with OJB (ObjectRelationalBridge) library

Architecture of GeOxygene

Which elements must be upgraded for 3D ?



Role of the pivot geometric model



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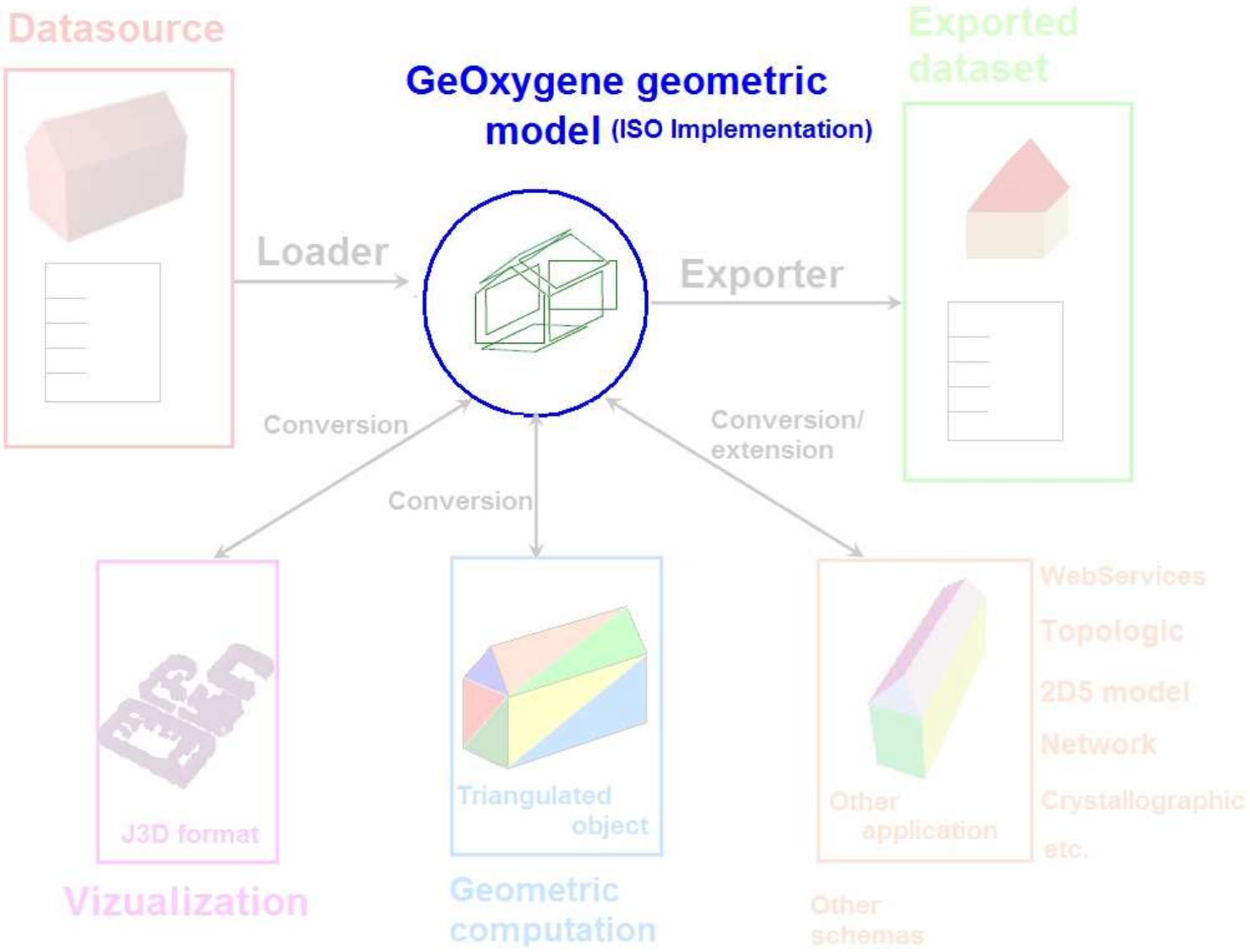
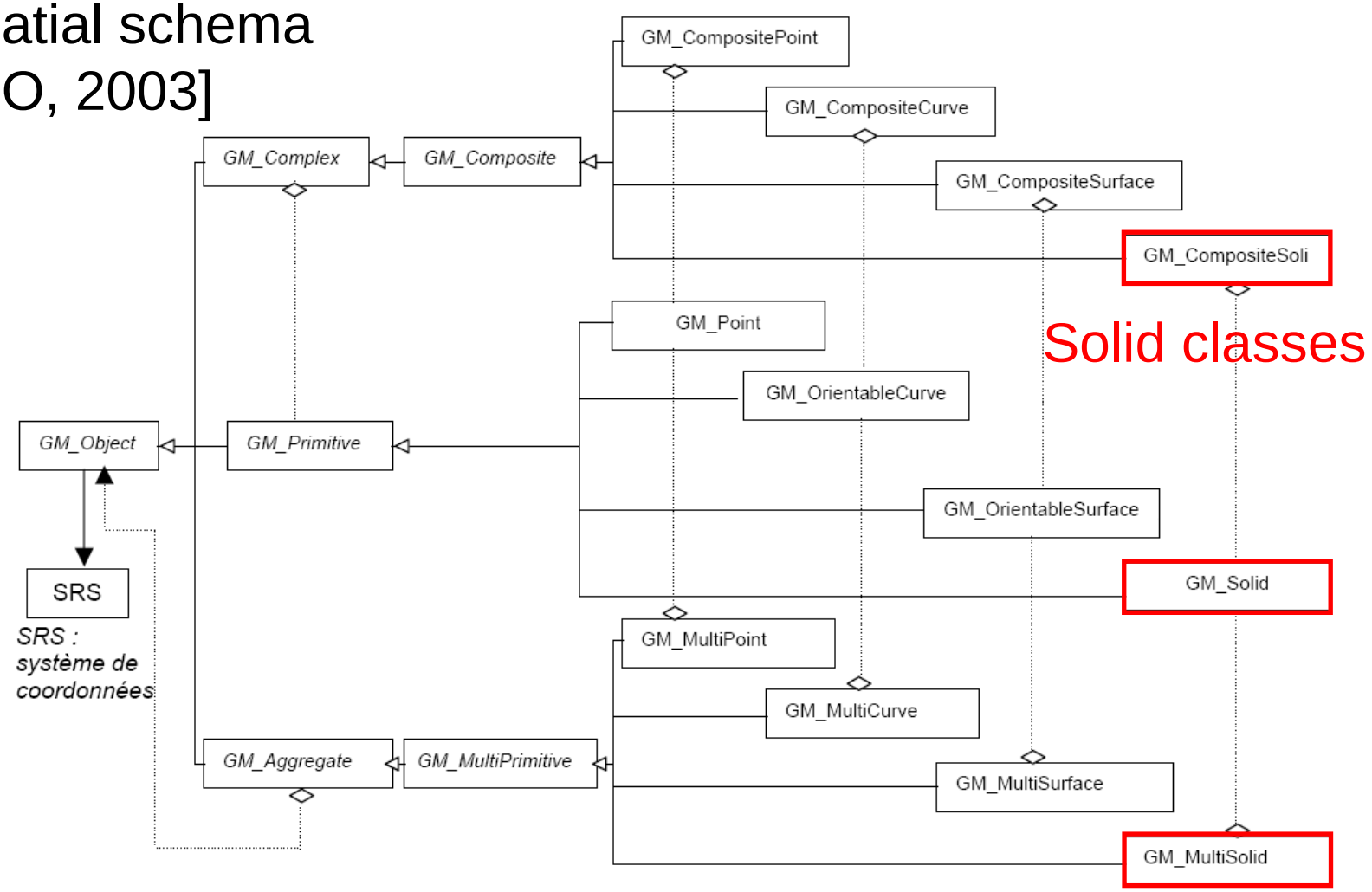


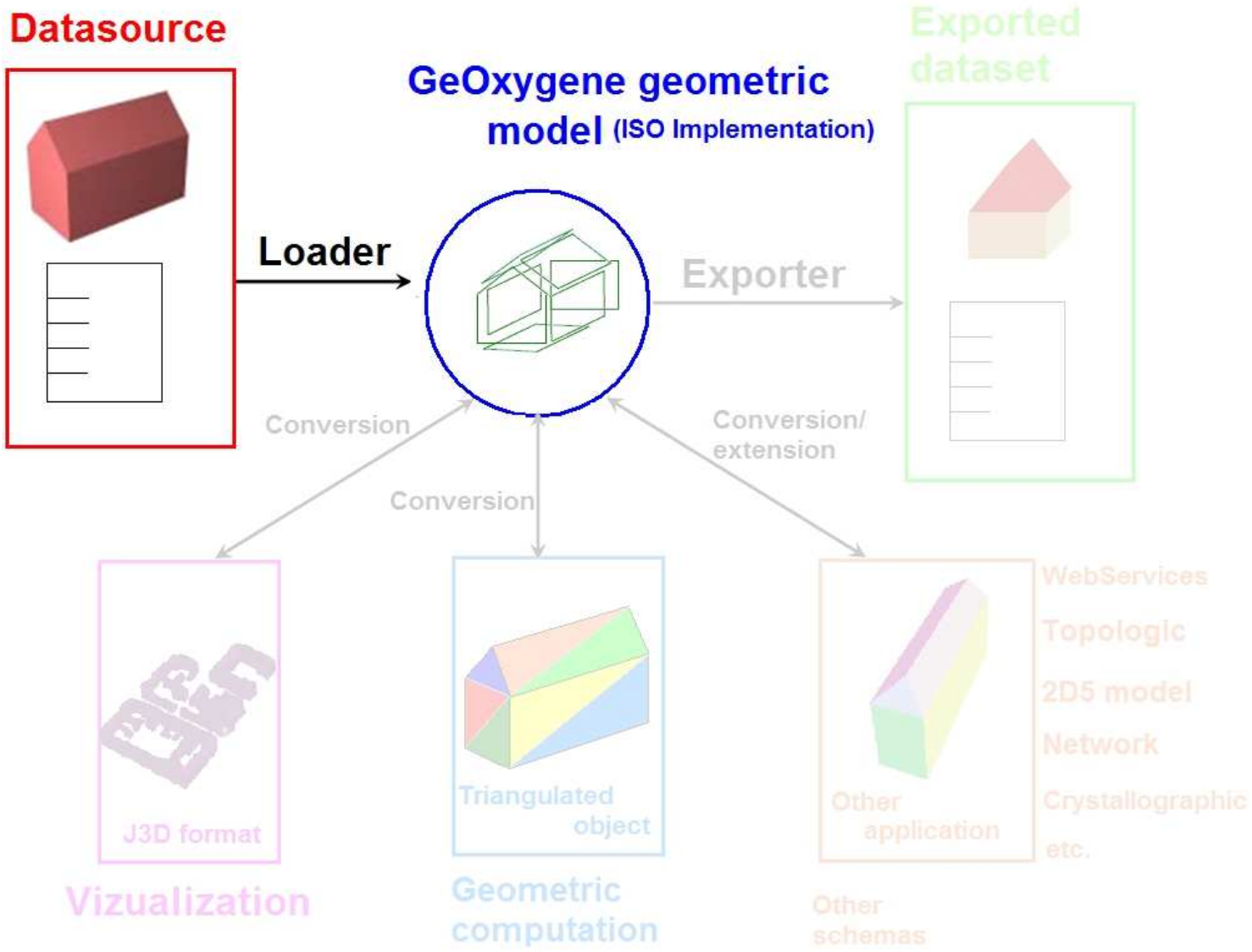
Which pivot geometric schema ?

Spatial schema
[ISO, 2003]



Solid classes

Role of the pivot geometric model



Which data can be loaded ?

GIS formats

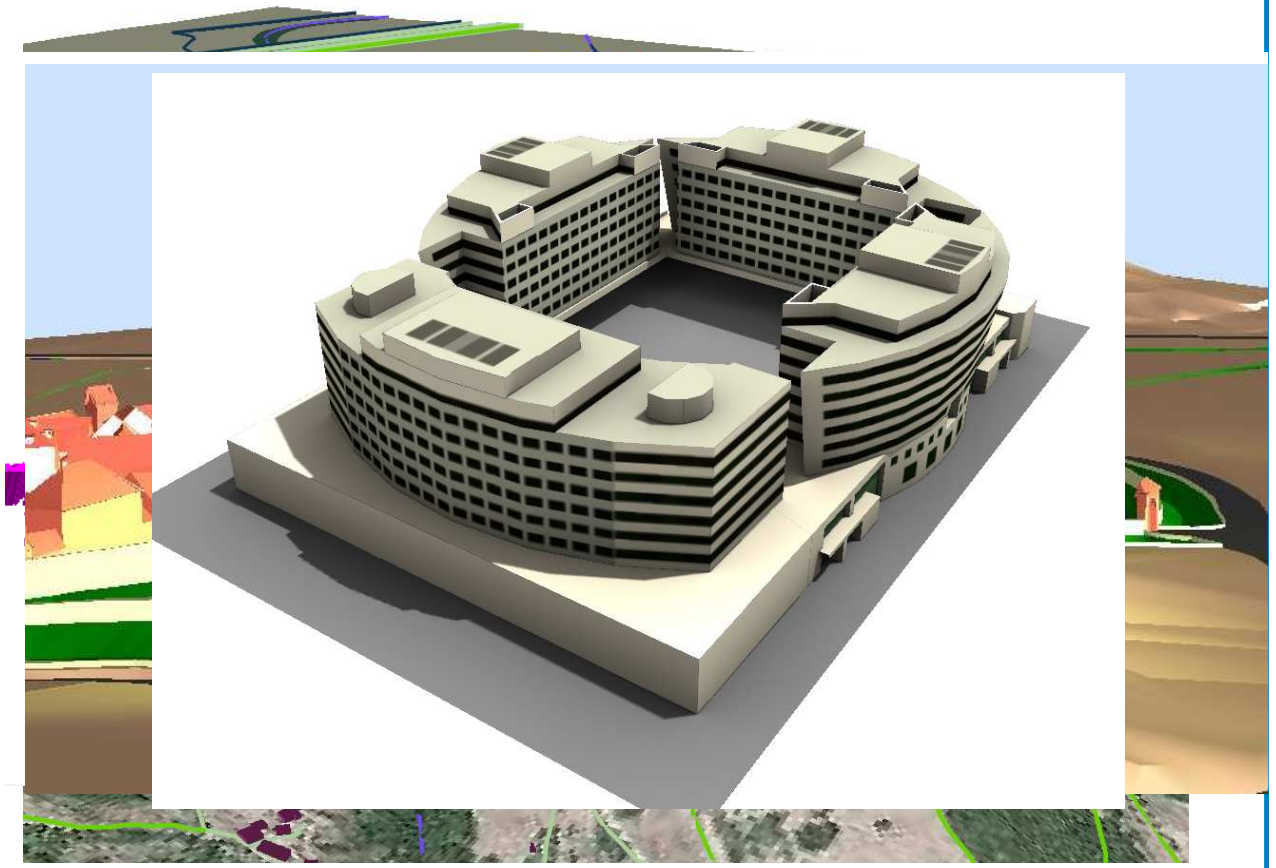
- ✓ Shapefiles
- ✓ DTM, orthophotos
- ✓ CityGML

3D modeling

- ✓.obj
- ✓.3Ds

DBMS format

- ✓ PostGIS

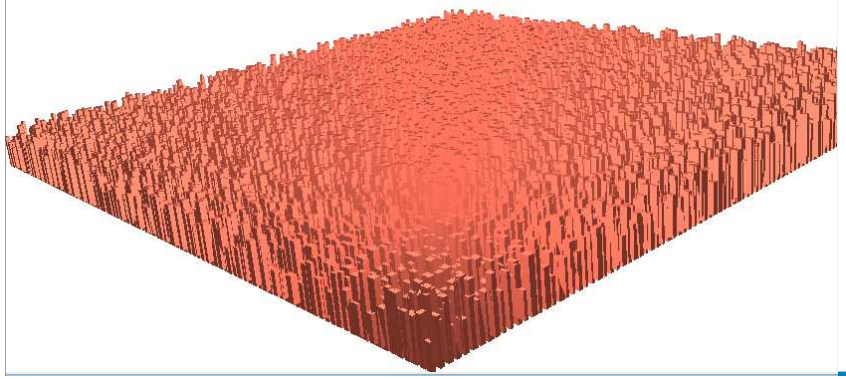


How to store geometries in PostGIS ?

PostGIS geometries
- ✓ POINT
- ✓ MULTIPOINT
- ✓ LINESTRING
- ✓ MULTILINESTRING
- ✓ POLYGON
- ✓ MULTIPOLYGON

in 3D but …..

~~✓ POLYHEDRALSURFACE~~
~~✓ POLYHEDRON~~



✓ Loading/storing in PostGIS 8.3 & PostGIS 1.3 with Ojb

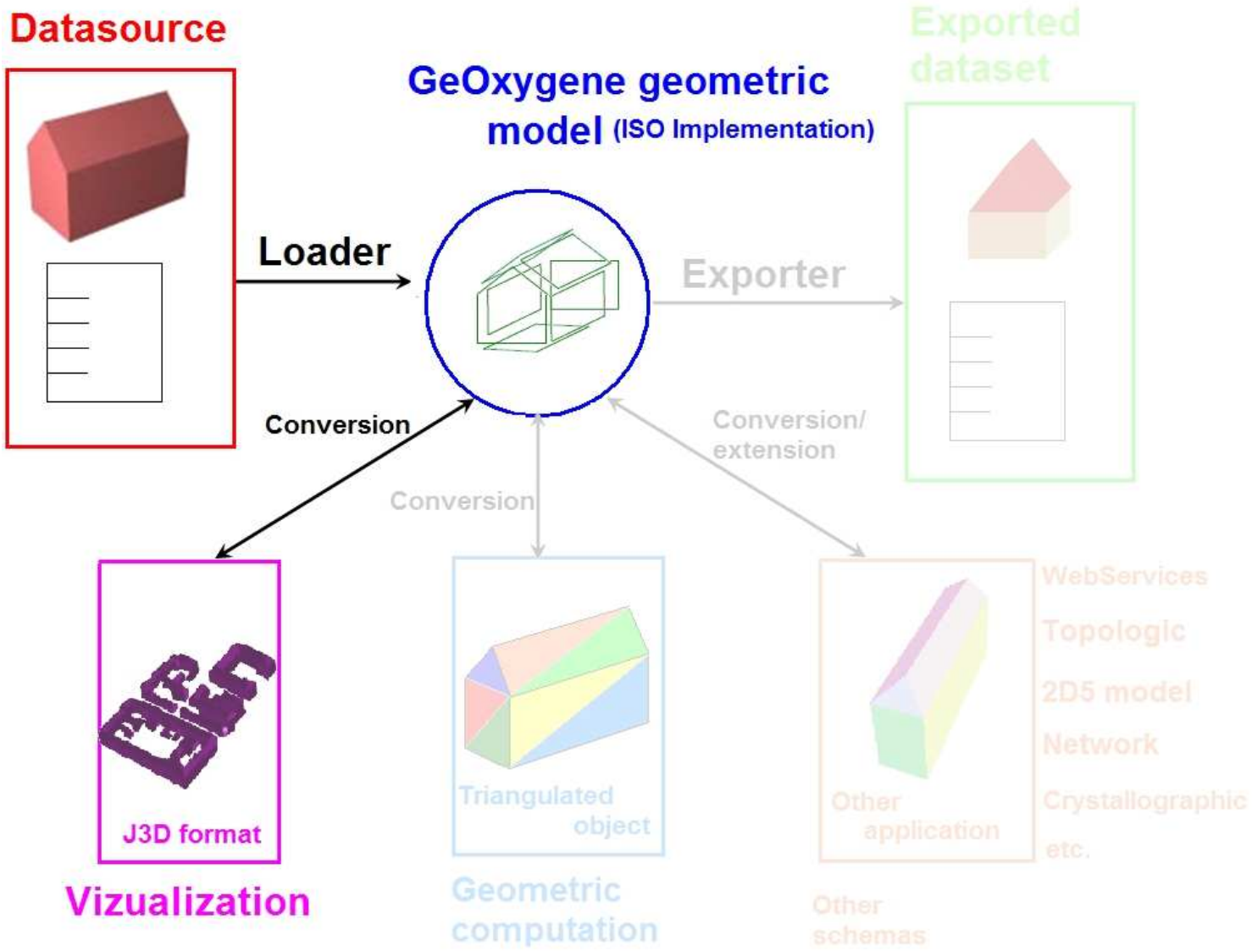
↳ Solid geometries stored as MultiPolygon with flag

✓ Loading ~ 8 s for 10 000 objects (4 s for an XML file)

✓ Storing ~ 10 s for 10 000 objects (6 s for an XML file)

↳ Future improvement : Implementation of a polyhedron type as described in [Khuan , 2008]

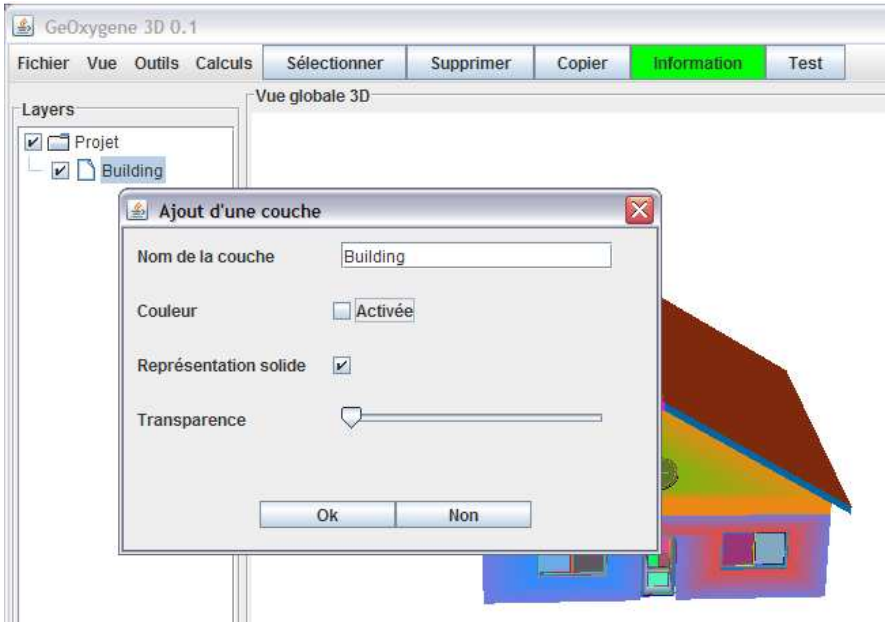
Role of the pivot geometric model



Visualization

How to represent the geometries ?

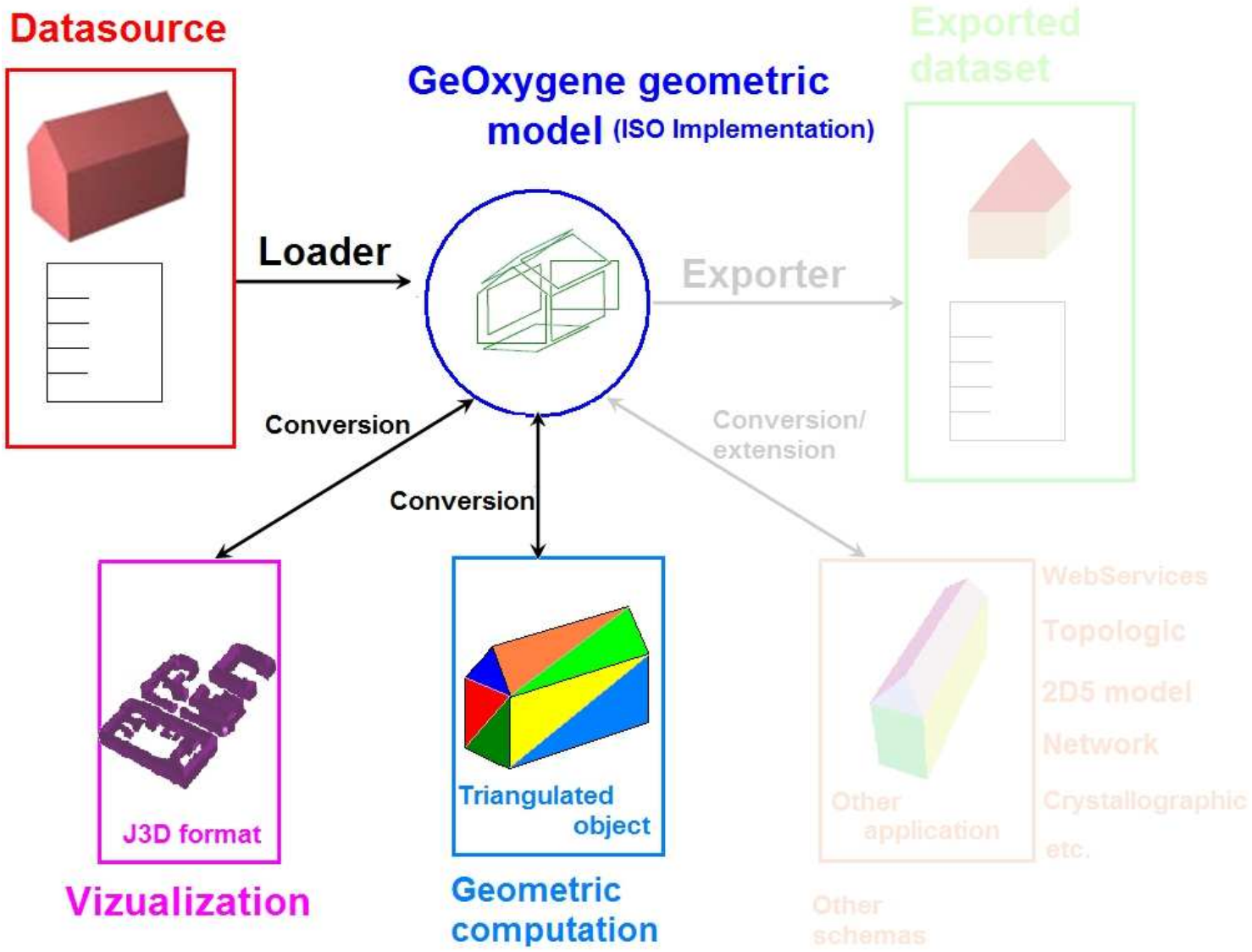
- ✓ Different representations for an object
- ✓ Choice of graphic library
  - ↳ Separation between feature and its representations
  - ↳ Use of Java3D



Functionalities

- ✓ 3D navigation
- ✓ Styled layer management
- ✓ Objects interrogation

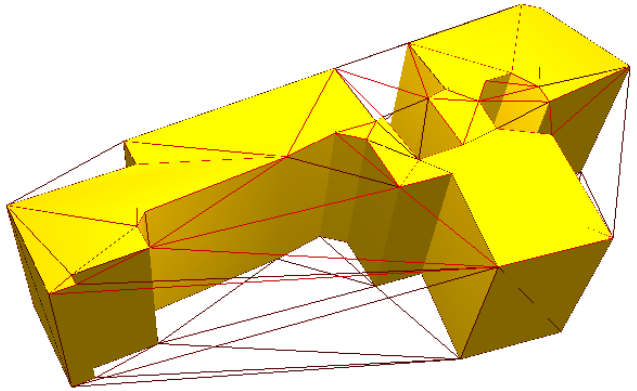
Role of the pivot geometric model



3D implemented functions

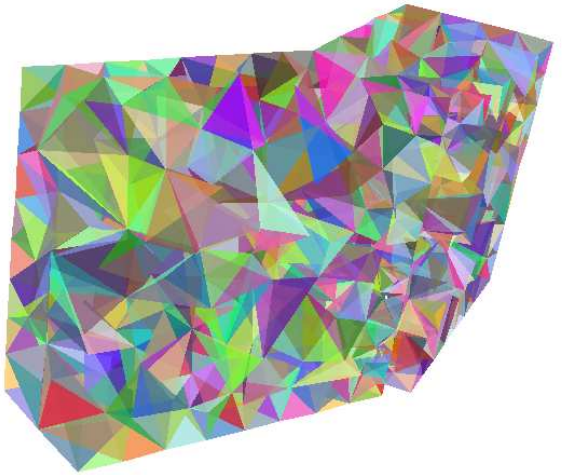
How to implement 3D operators ?

- ✓ Current library JTS only for 2D
- ✓ Java open-source libraries uncommon



Selection of libraries

- ✓ Solid decomposition (TetGen [Hang Si, 2006])
- ✓ Boolean operators (JGeom [Frick, 2004])



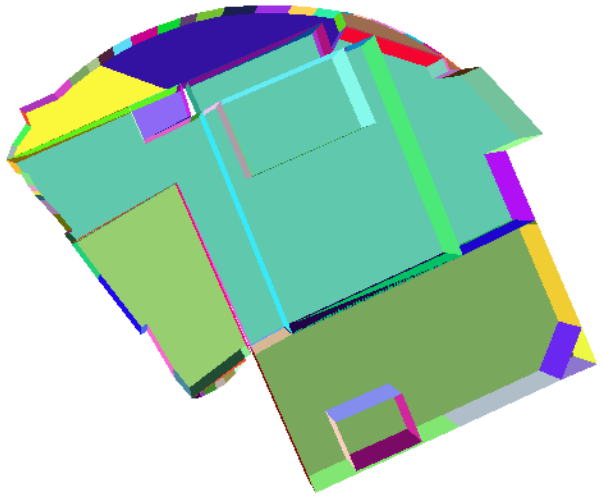
Implementation

- ✓ Offsetting
- ✓ Convex hull
- ✓ Others (Center of gravity, volume …)

↳ Providing functions described in the ISO specifications

Geometric issues

What about processing on geometries loaded ?



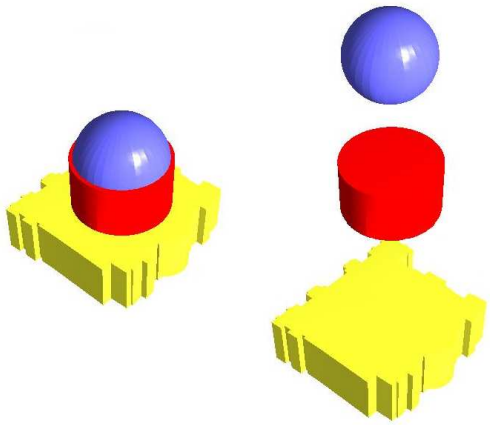
The meaning of what is a facet differs between datasets

- A facet is not equivalent to a wall
- The dome is an entire sphere

Bottomless buildings or bad face orientation cause

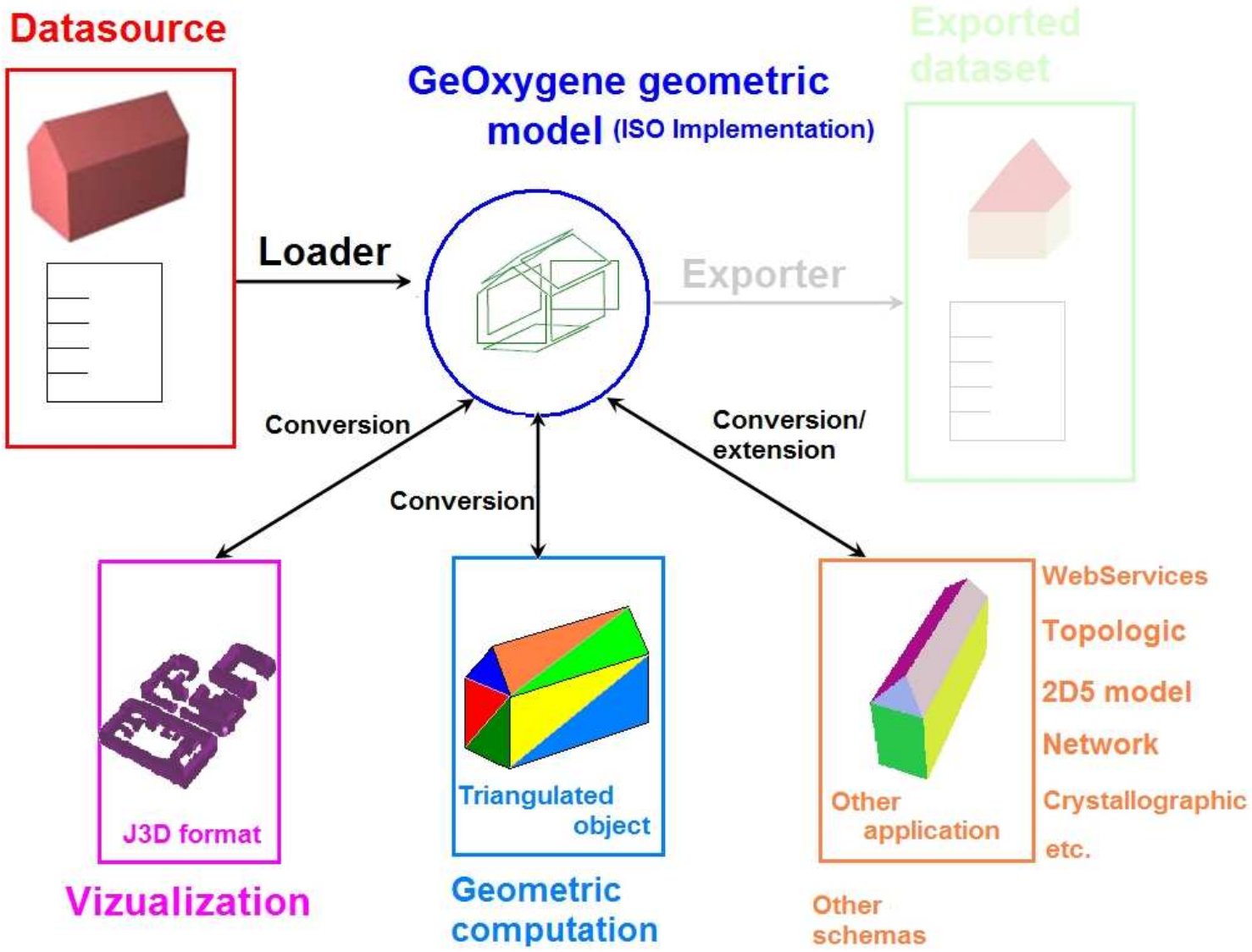
- Constrained tetrahedrization
- Boolean operators

not to be computable



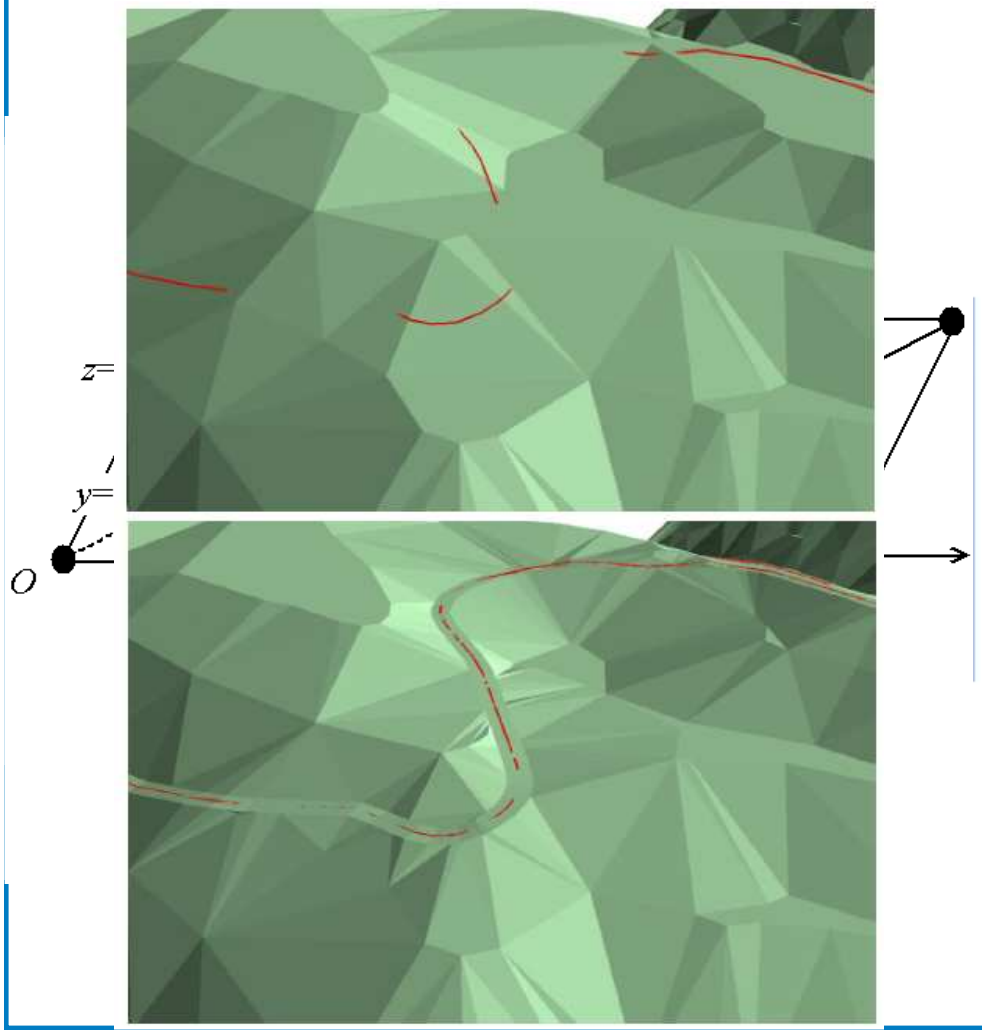
↳ Need to develop tools to correct or to detect unexpected geometries

Role of the pivot geometric model



Different models for analysis

Which other models ?



✓ De La Losa [2000]
Topologic

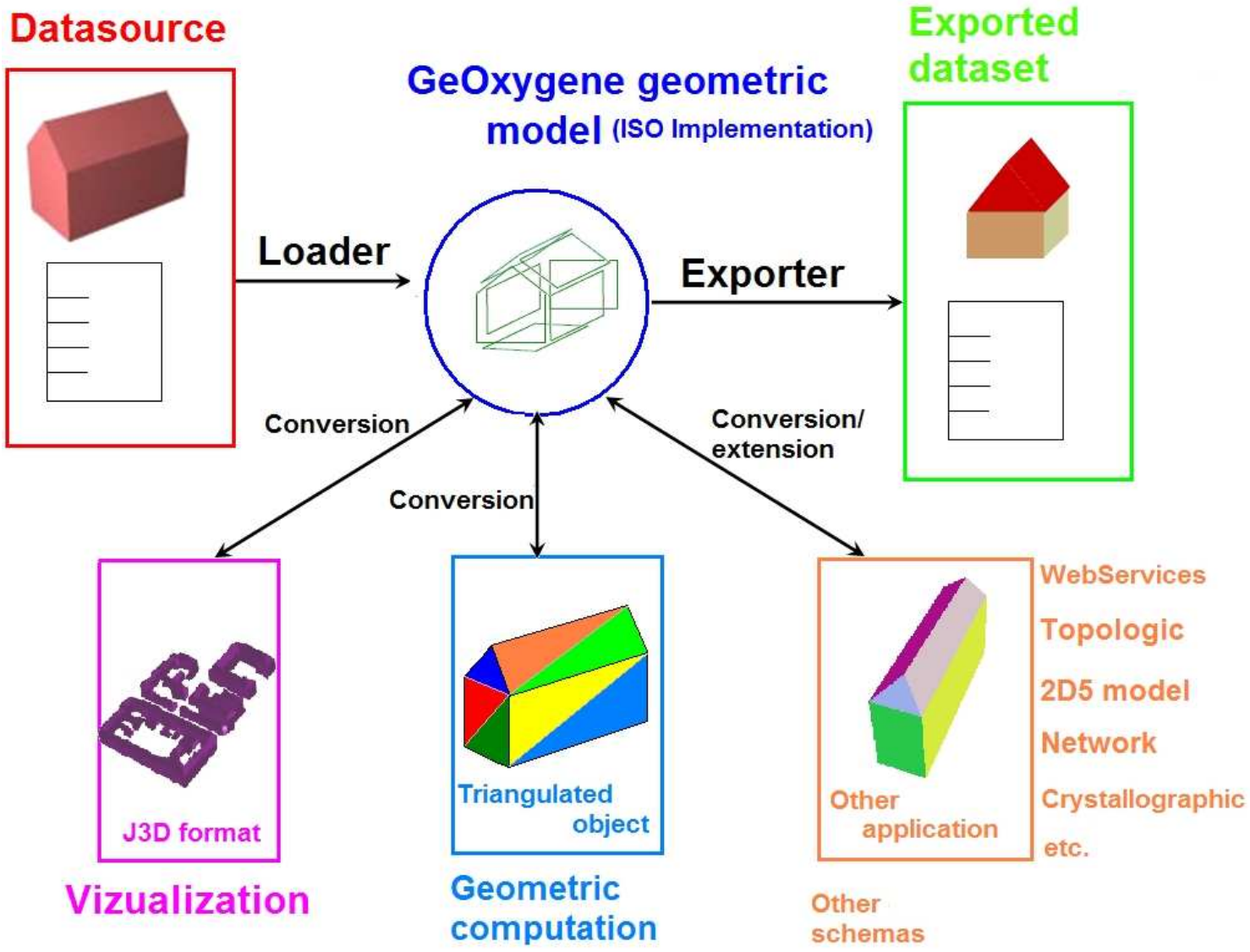
✓ Ramos [2003]
Network & intervisibility

✓ Rousseaux [2004]
2D5 model

✓ Poupeau [2008]
Crystallographic

↳ Different points of view on 3D to integrate on 1 platform

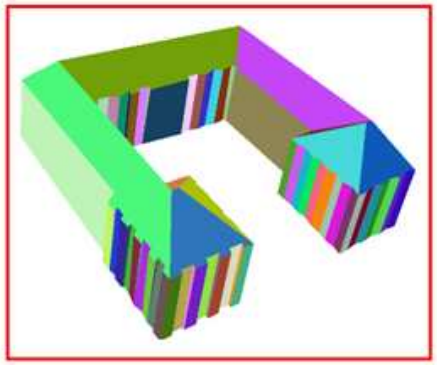
Role of the pivot geometric model



Framework application

TerraNumerica project
(Collaboration with French IT industries)

- ✓ Acquisition and representation of 3D databases
- ✓ Framework used to develop an algorithm of 3D building generalization

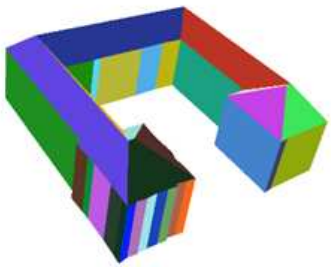
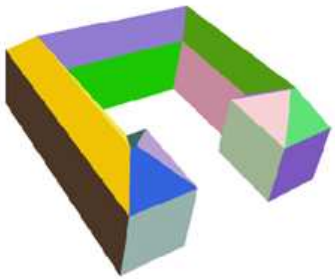
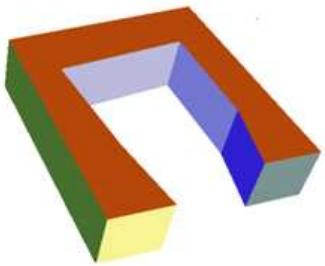
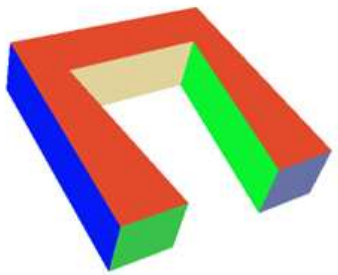


Initial building

Simplification by buffer merging and reconstruction

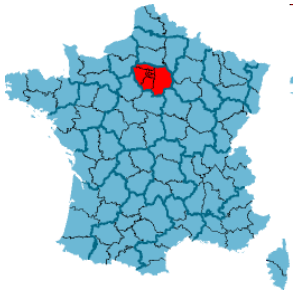
✓ Based on [Kada, 2007]

Parameter	0	1	2	5	10
Number of facets	312	32	25	10	9
Time in ms		41	41	37	35

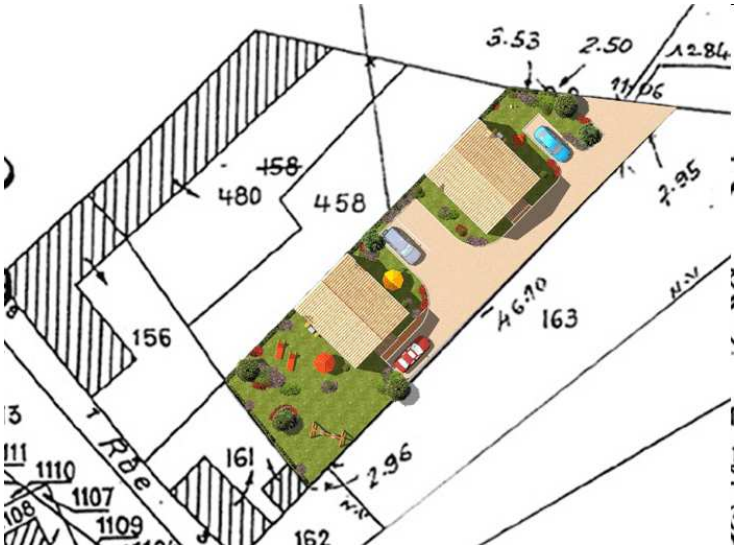
TerraMagna project

(Collaboration with French IT industries)



Main goals

- ✓ Realize a 3D GIS on “Ile-de-France” region (Paris & neighborhood area)
- ✓ Application about environment



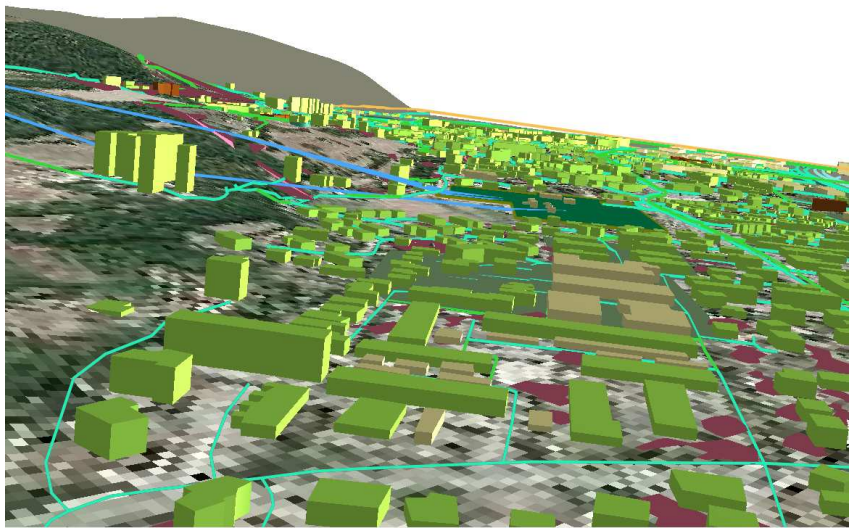
2 missions for the framework

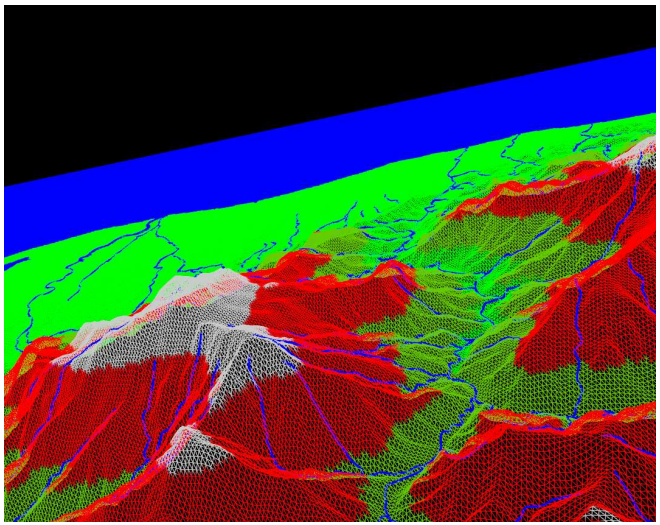
Development of 3D geometric functions

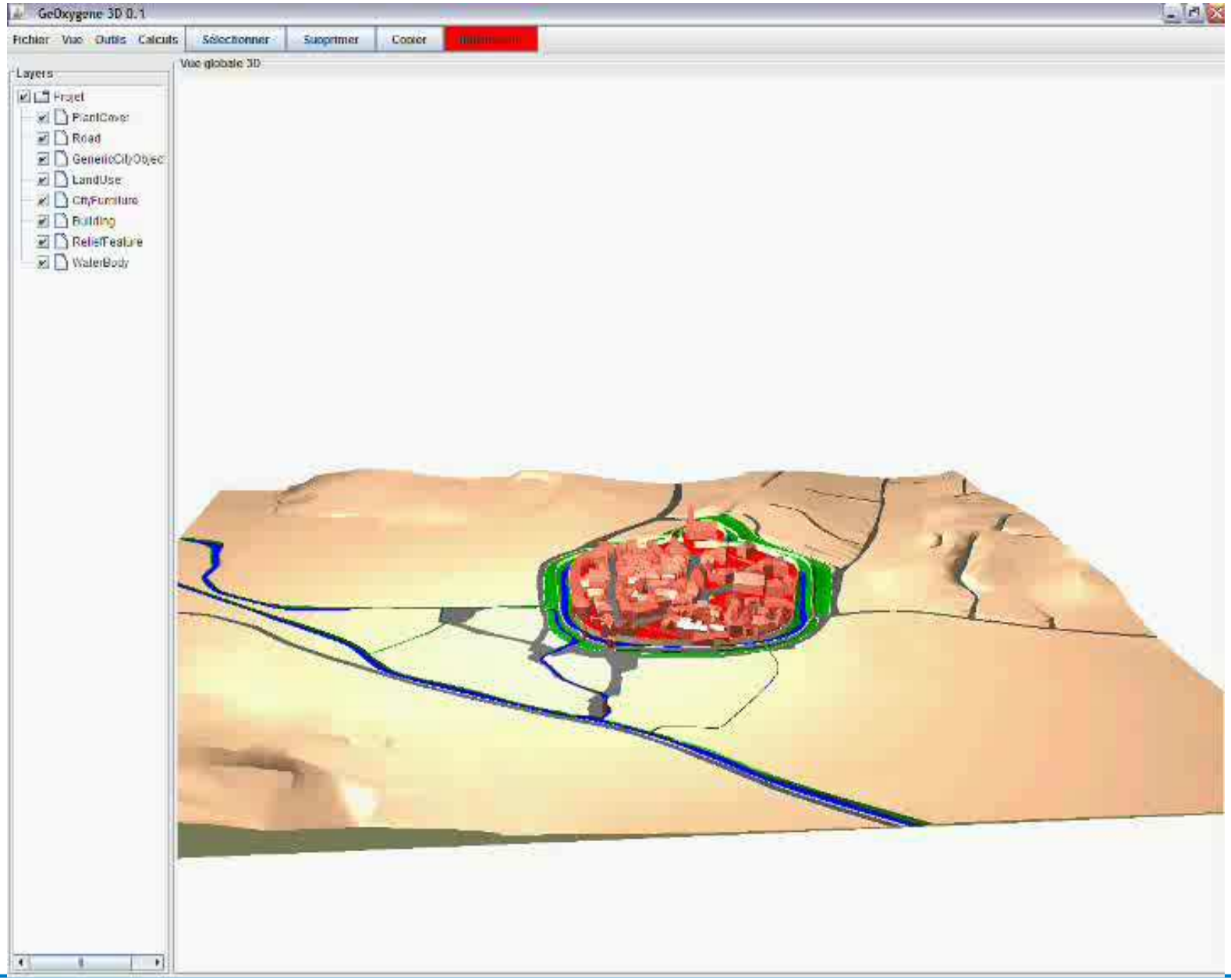
3D editor of rules of urban design

Conclusion

- ✓ Framework release for the late 2009 with presented features
- ✓ All code is Open-source
- ✓ Functional 3D core
- ✓ Default interface
- ✓ Extendable geometric schema to capitalize different works
- ✓ ISO geometric functionalities provided






GeOxygene 3D 0.1
Fichier
Vue
Outils
Calculs
Sélectionner
Supprimer
Copier
Layers
Projet
PlantCover
Road
GenericCityObject
LandUse
CityFurniture
Building
ReliefFeature
WaterBody
Vue globale 3D

Any questions ?

GeOxygene website : http://oxygene-project.sourceforge.net/

E-mail : mickael.brasebin@ign.fr

Reserve

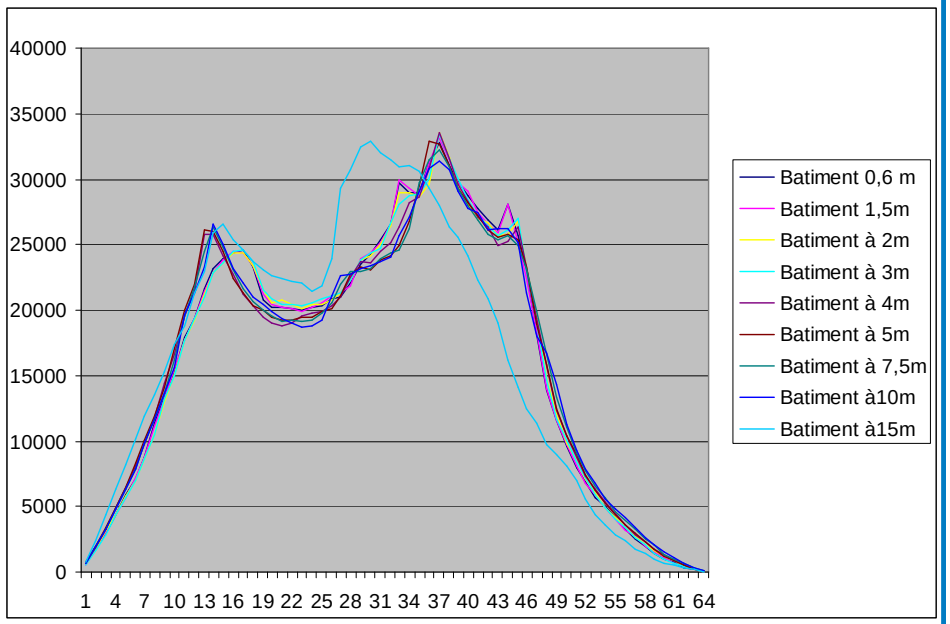
Dissimilarity calculation

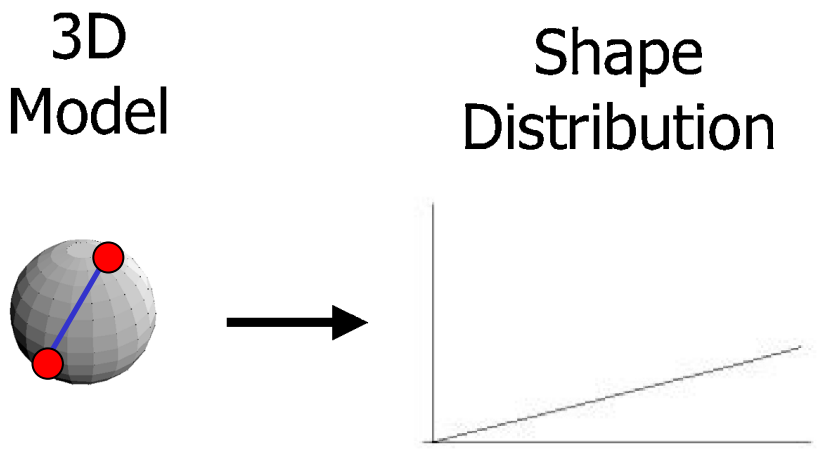
- ✓ Based on [Osada, 2002]

Goals

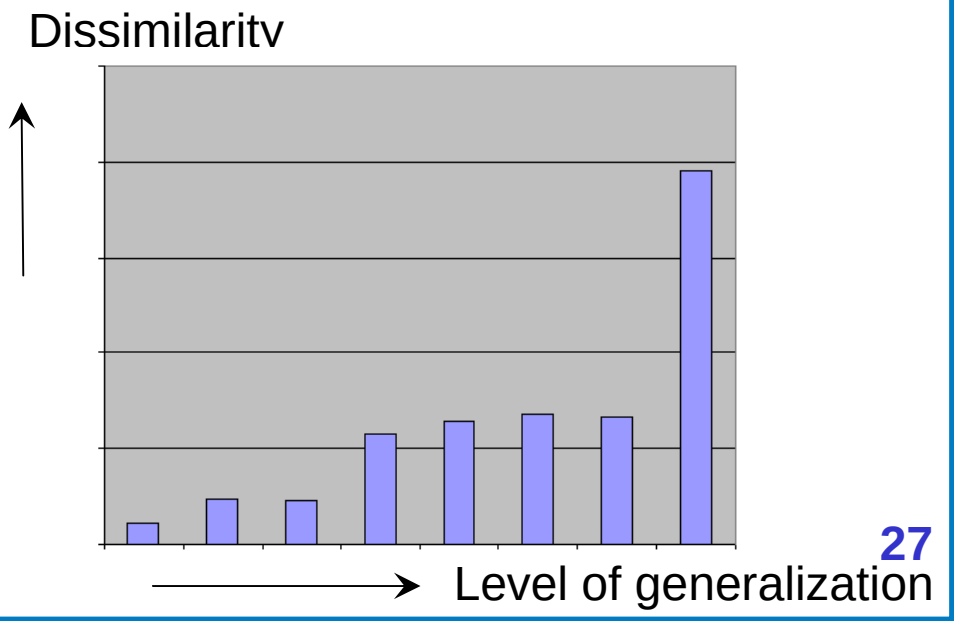
- ✓ Check similarity between initial object and simplified one
- ✓ Determine threshold
- ✓ Classify buildings

Compare the distribution of distances in the shape





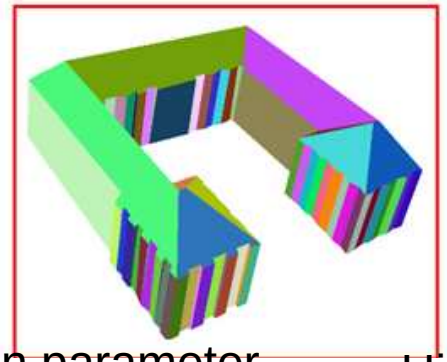
[Osada 2002]



Building generalization

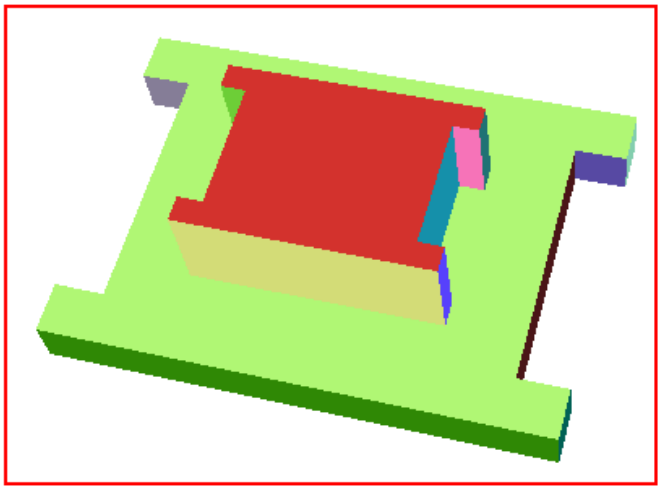
✓ Based on [Kada, 2007]

Simplification by buffer merging and reconstruction

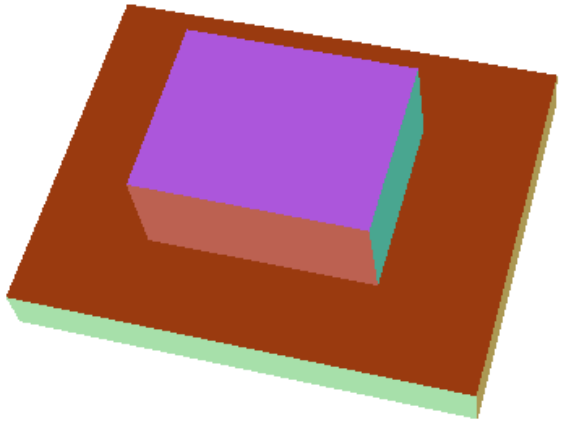


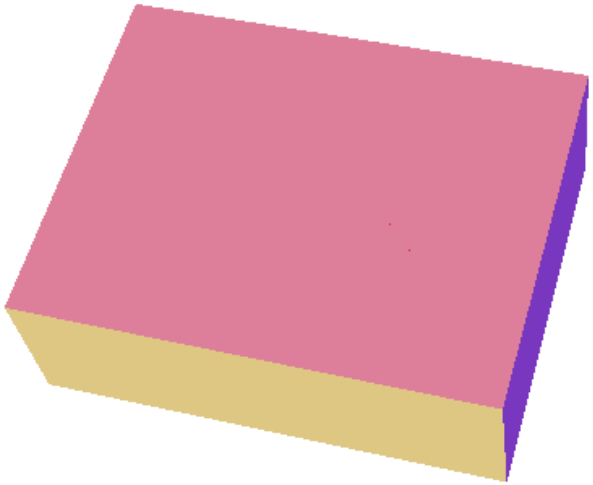
Initial building

Low Z-fusion parameter



High Z-fusion parameter





Fast algorithm effective with Bati3D buildings

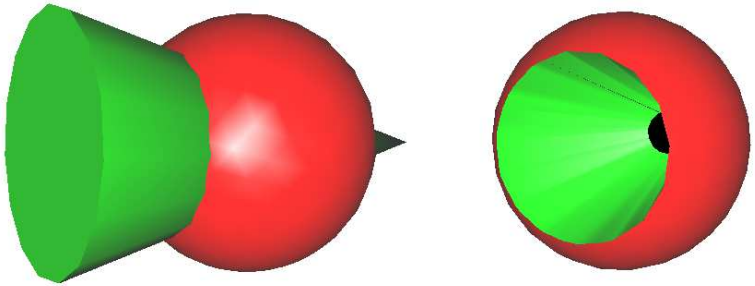
↳ Next step : comparison with others algorithms

Parameter	0	1	2	5	10
Number of facets	312	32	25	10	9
Time in ms		41	41	37	35

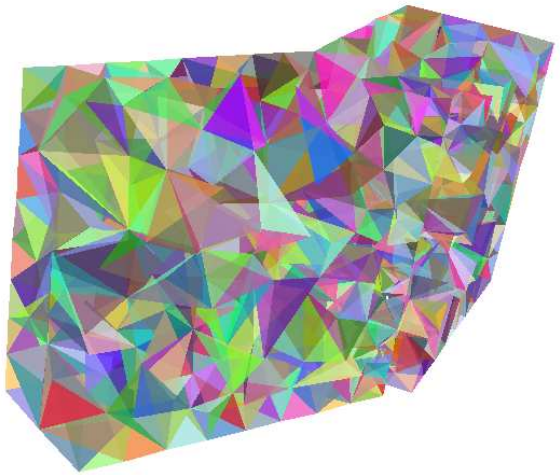
3D implemented functions

Geometric operators

✓ Boolean operators
(Intersection, union …)



✓ Solid decomposition
(Into triangles, tetrahedrons …)



✓ Common calculation
(Volume, center of gravity…)

✓ Convex hull calculation, offsetting etc.

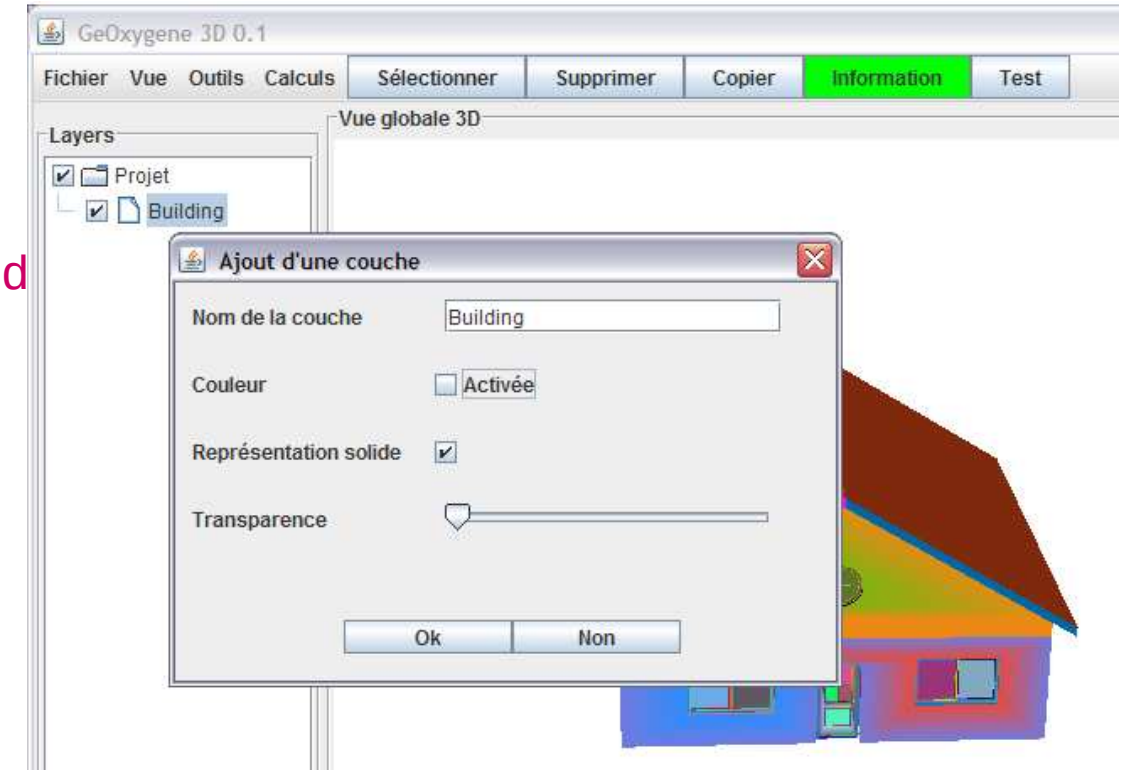
Use of selected open source libraries :
TetGen [Hang Si, 2006] and JGeom [Frick, 2004]

Viewer

Technologies

- ✓ Swing Interface
- ✓ Java3D for rendering

↳ Separation between core and representation model

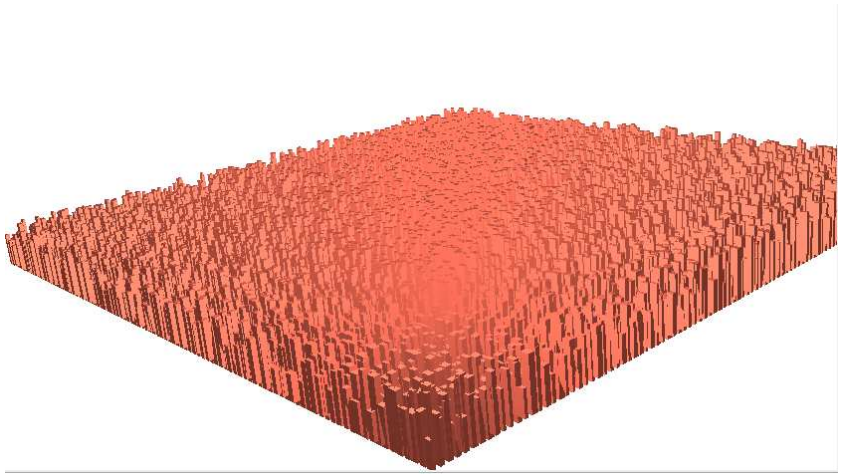


Functionalities

- ✓ 3D navigation
- ✓ Styled layer management
- ✓ Objects interrogation

PostGIS Loader

✓ Loading/storing in PostGIS 8.3 & PostGIS 1.3 with Ojb



PostGIS geometries

- ✓ POINT
- ✓ MULTIPOINT
- ✓ LINESTRING
- ✓ MULTILINESTRING
- ✓ POLYGON
- ✓ MULTIPOLYGON

~~✓ POLYHEDRALSURFACE~~
~~✓ POLYHEDRON~~

Results

✓ Loading ~ 8 s for 10 000 objects
(4 s for an XML file)

✓ Storing ~ 10 s for 10 000 objects
(6 s for an XML file)

⇨ Solid geometries stored
as MultiPolygon with flag

↳ Future improvement :
Implementation of a
polyhedron type as
described in [Khuan , 2008]

References

Frick Urs, Gerber Samuel, 2004, Boolean Operators for Java 3D

Hang Si, 2006, TetGen : A Quality Tetrahedral Mesh Generator and Three-Dimensional Delaunay Triangulator

ISO, 2003, Geographic information — Spatial Schema ISO Draft International Standard 19107:2003.

Kada M., 2007, 3D Building Generalisation by Roof Simplification and Typification. in proceedings of ICC2007, the International Cartography Association Conference, Moscow (Russia), 2007.

Khuan C.T., Abdul-Rahman A. and S. Zlatanova, 2008, New 3D data type and topological operations for Geo-DBMS In: V. Coors, M. Rumor, E. Fendel and S. Zlatanova (Eds.); Urban and regional data management: UDMS annual 2007, Taylor & Francis, 2008, pp. 211-222

Oasada, R., Funkhouser T., Chazelle B., and Dobkin, D. 2002. Shape distributions. ACM Trans. Graph. 21, 4, 807–832.