

UNDERSTANDING URBAN DYNAMICS

THE USE OF VECTOR TOPOGRAPHIC DATABASES AND THE CREATION OF SPATIO-TEMPORAL DATABASES

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Context

Understanding urban dynamics is an important challenge

To tackle this problem, we need:

- to build **spatio-temporal databases**
- to be able to **track the evolutions of topographic objects**
- a **simulation platform** to test hypotheses

The **GeOpenSim project** addresses these issues

Outline

- ① Introduction: The GeOpenSim project
- ② Creating Spatio-temporal databases from topographic data
 - Existing maps and data
 - Creation of spatio-temporal databases
 - Tracking objects in time
- ③ Representing spatio-temporal data and simulation
 - A multi-level representation and its construction
 - Representations and agents
 - Agents and simulation
- ④ Conclusion

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The GeOpenSim project (2007-2010)

collaboration between researchers from

- **COGIT**-Geomatics- IGN, Paris (France)
- **LSIIT**-Computer Science- Strasbourg (France)
- **LIVE**-Geography- Strasbourg (France)

coordinated by **Anne Ruas**, director of the COGIT Lab
funded by the **French National Research Agency (ANR)**



The GeOpenSim project's goal

to provide an open source framework to study urban dynamics

depends on **GeOxygène**, an open source GIS
organized in modules:

- ① building spatio-temporal databases
- ② spatial analysis and data enrichment
- ③ simulation
- ④ building evolution rules
- ⑤ state evaluation

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Existing topographic database: BD Topo®

vector geodatabase

metric precision (adapted to the scale of 1:5 000 to 1:25 000)

thematic categories

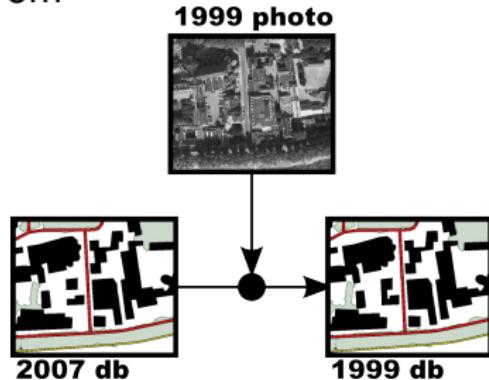
- Communication axes
- Railway
- Energy transport
- Hydrography
- Buildings
- Relief
- Administrative limits
- Vegetation



Existing complementary data

topographic databases only available for the most recent dates
historical information is collected from

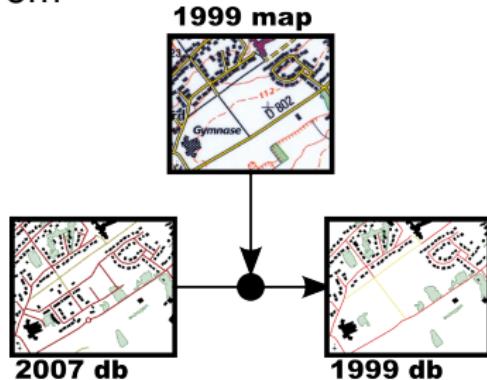
- older **aerial photographs**
- older topographic maps



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Existing topographic maps

for instance, for Orléans

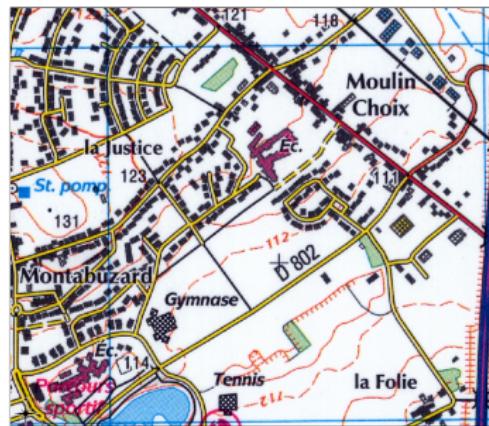
- **2007 database**
- 1999 map
- 1989 map
- 1978 map
- 1957 map



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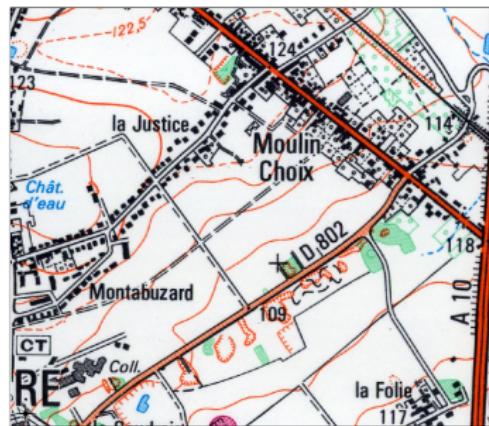
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Existing topographic maps

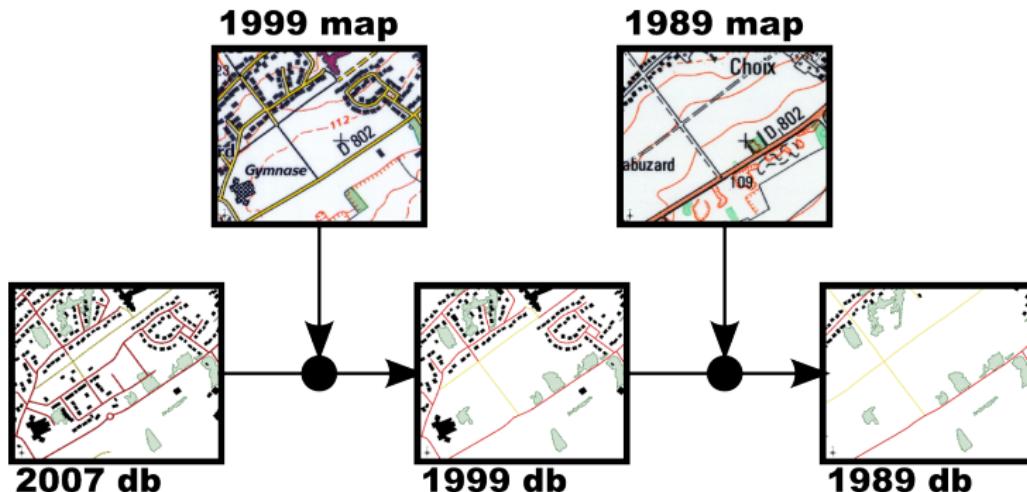
for instance, for Orléans

- 2007 database
- 1999 map
- **1989 map**
- 1978 map
- 1957 map



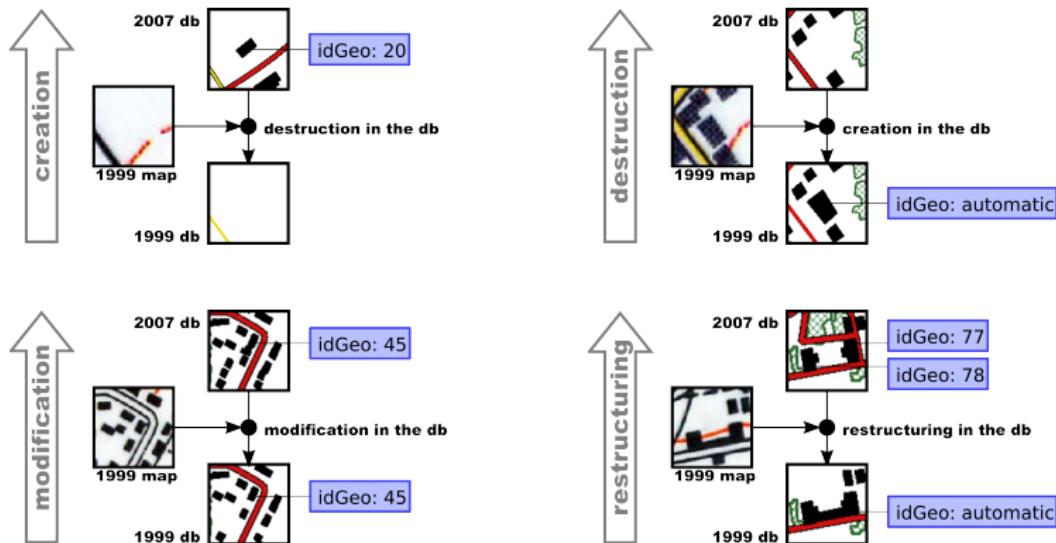
Down-dating: creating spatio-temporal databases

manual modification of each topographic database
going back in time, date by date, **sequentially**



Identifying object evolutions

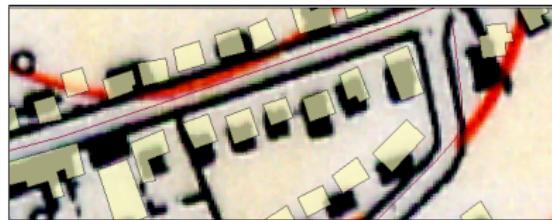
each object has an identifier **idGeo** common in each database used for tracking its evolutions during its entire lifetime



Limits of the method

Maps

- generalization process
- identification of evolutions is not trivial



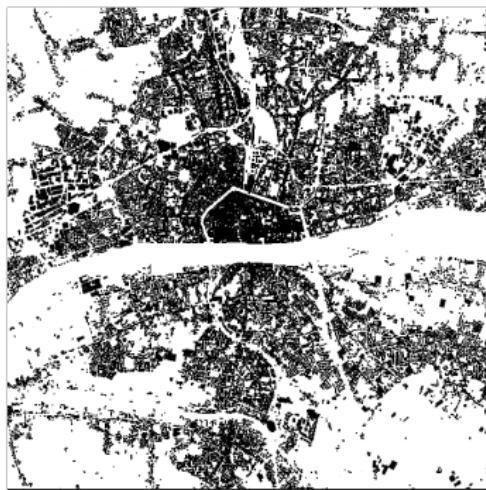
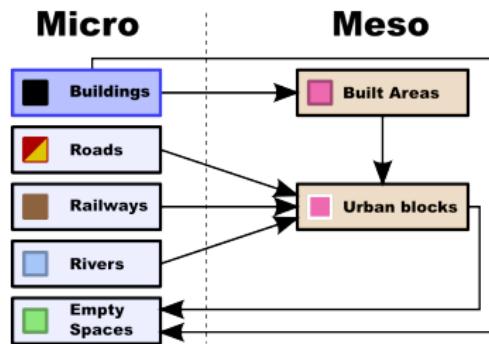
Photos

- interpretation can be complicated on old photos
- coverage is not always as good as we'd like

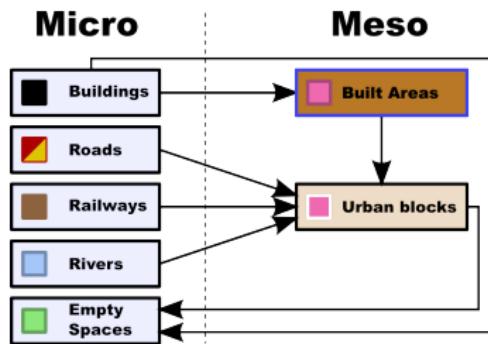
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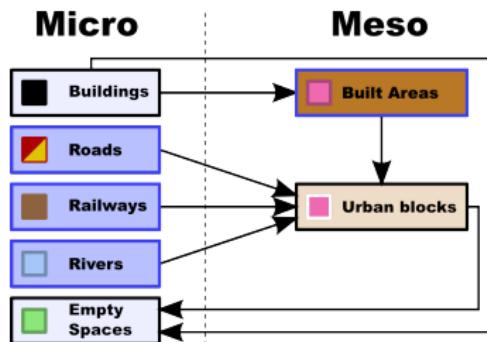
Hierarchy creation process



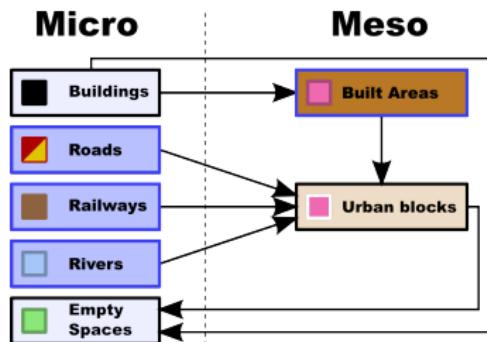
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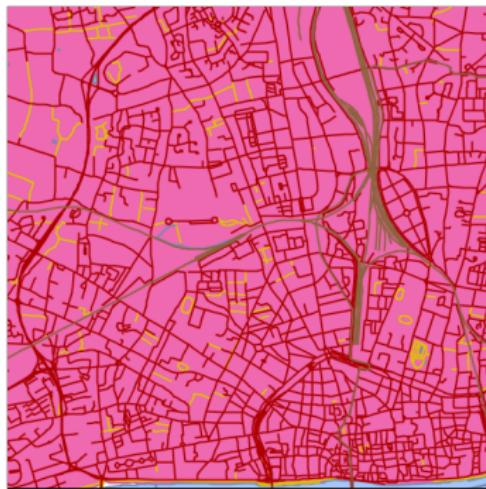
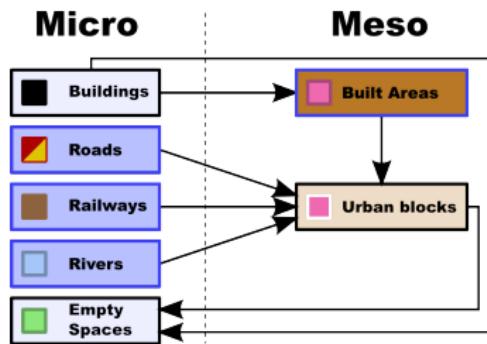
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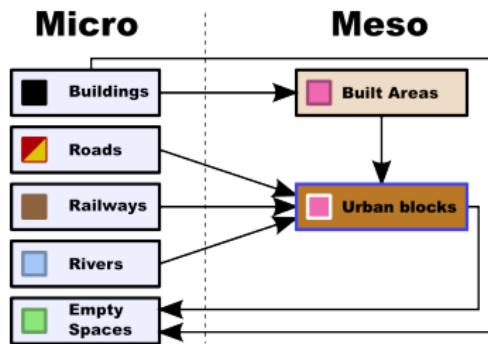
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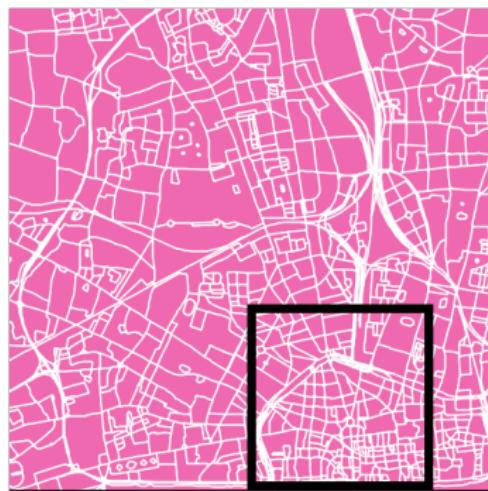
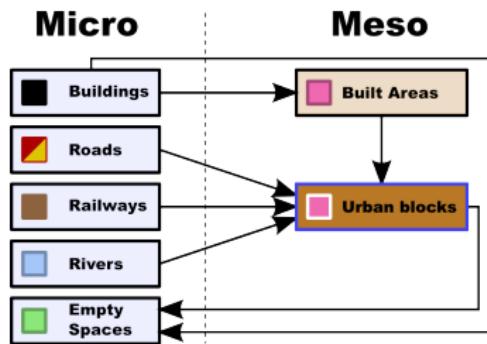
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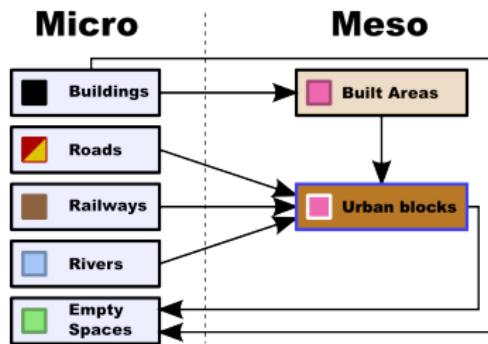
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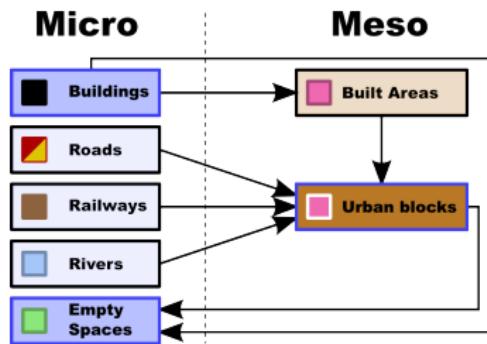
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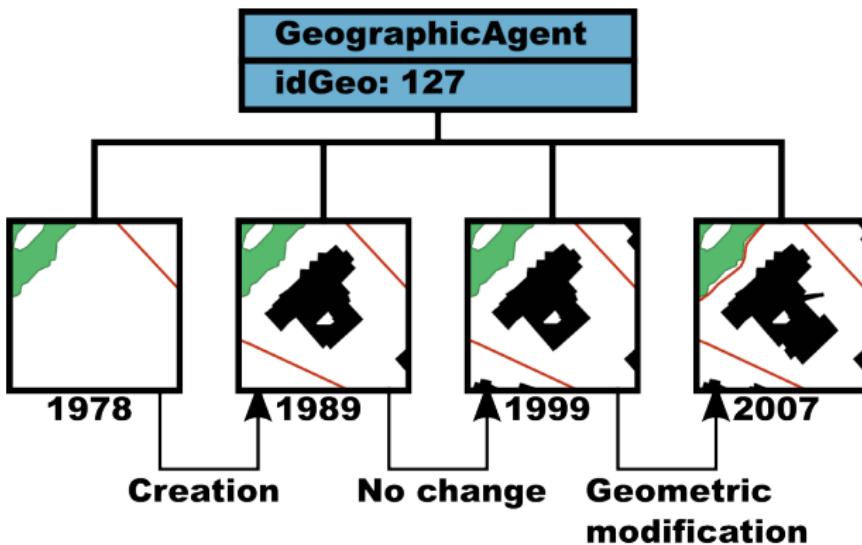
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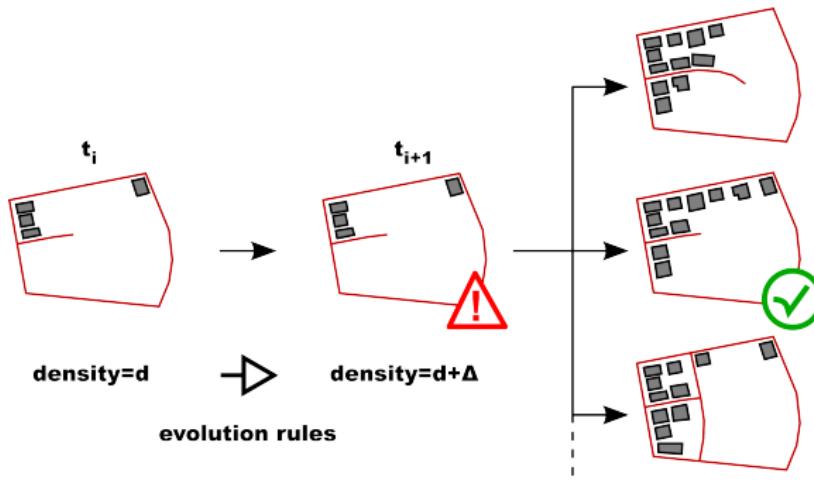


An agent and its representations



Evolution Rules

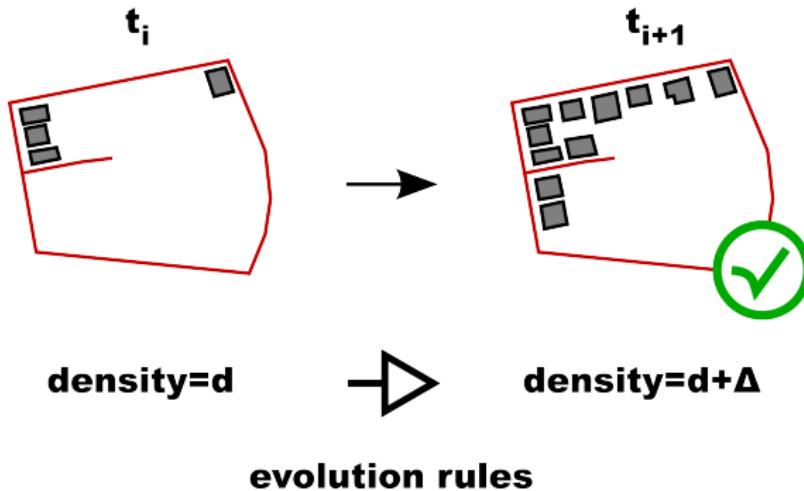
Evolution rules **set target measure values** to agents
Agents do their best to **reach those values**



Evolution rules are applied to all agents for each simulation

Evolution Rules

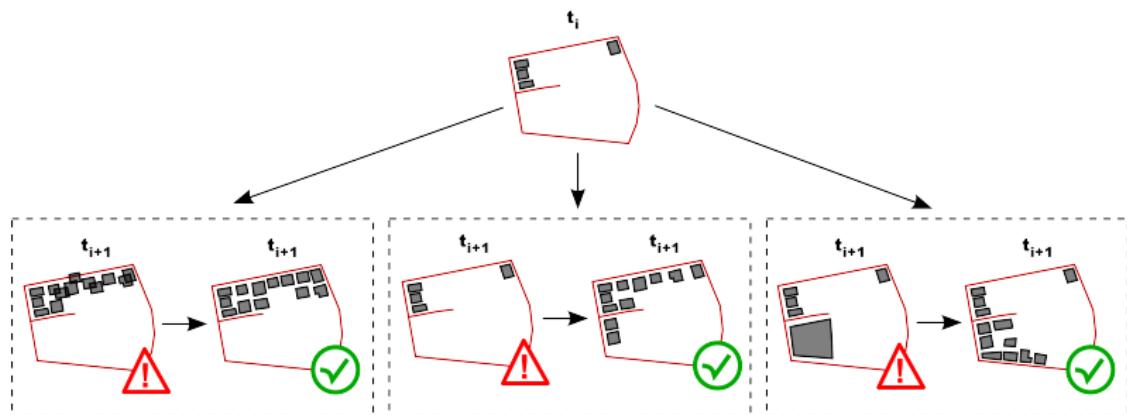
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Evolution rules are applied to all agents for each simulation

Constraints

- help the agents reach their goals
- propose **potential actions** to try



A simulation example

urban blocks densification
by making new buildings



Work done with **Florence Curie**, IGN

A simulation example

urban blocks densification
by making new buildings



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We proposed

- **a spatio-temporal database creation process**
 applied to several test areas
- **a data enrichment process**
 including urban blocks creation
- **a multi-agent system**
 to simulate evolutions
- **an open source platform**
 to collaborate with other researchers

This should help to better understand urban dynamics...

Coming up next. . .

- **evolution rules construction:**
using expert hypotheses and machine learning
- **state evaluation:**
comparing simulations with reality
- **new simulation behaviors:**
urban blocks split, etc.
- **enhancing creation of historical db:**
integration of new data using a data matching tool
using expert generalization knowledge

Thank you for your attention...



... and see you in Paris in 2011!

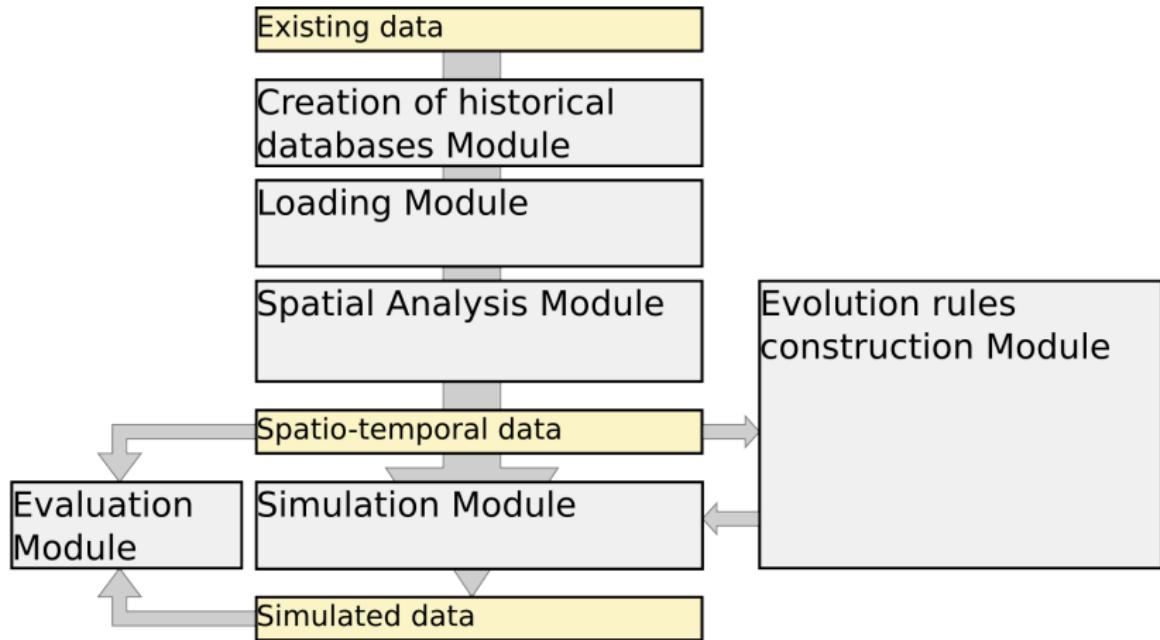


<http://www.icc2011.fr/>

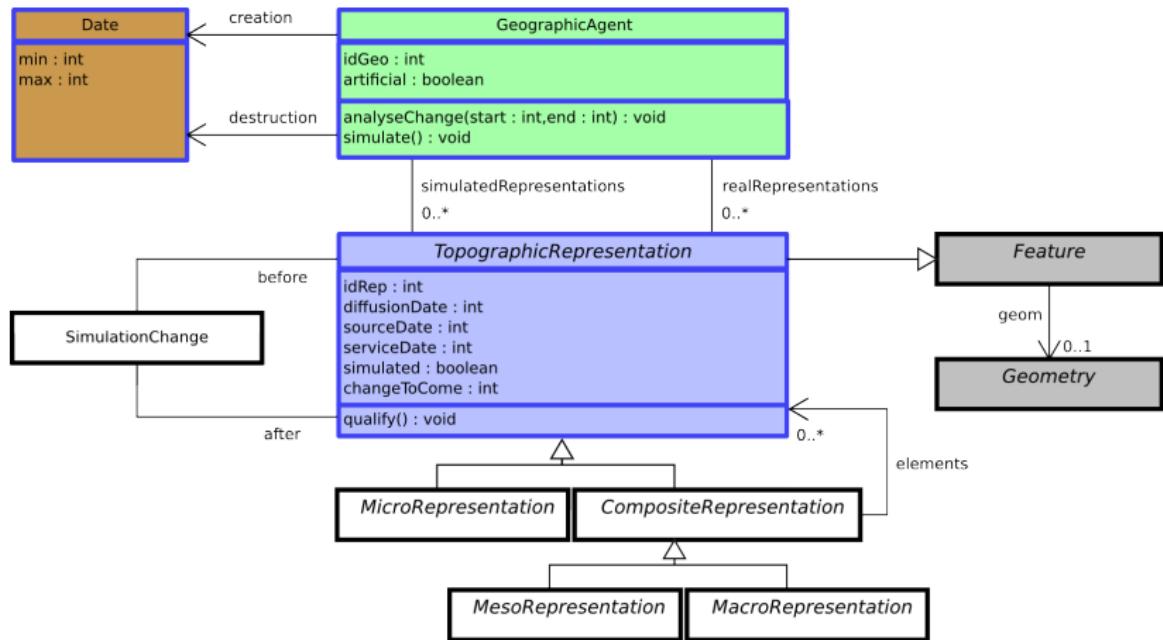
Bonus tracks (free of charge)

- ▶ GeOpenSim modules
- ▶ GeOpenSim class diagram
- ▶ GeOpenSim sample data
- ▶ GeOpenSim tracking view
- ▶ The Louvre as an agent
- ▶ A constraint example
- ▶ An agent's life

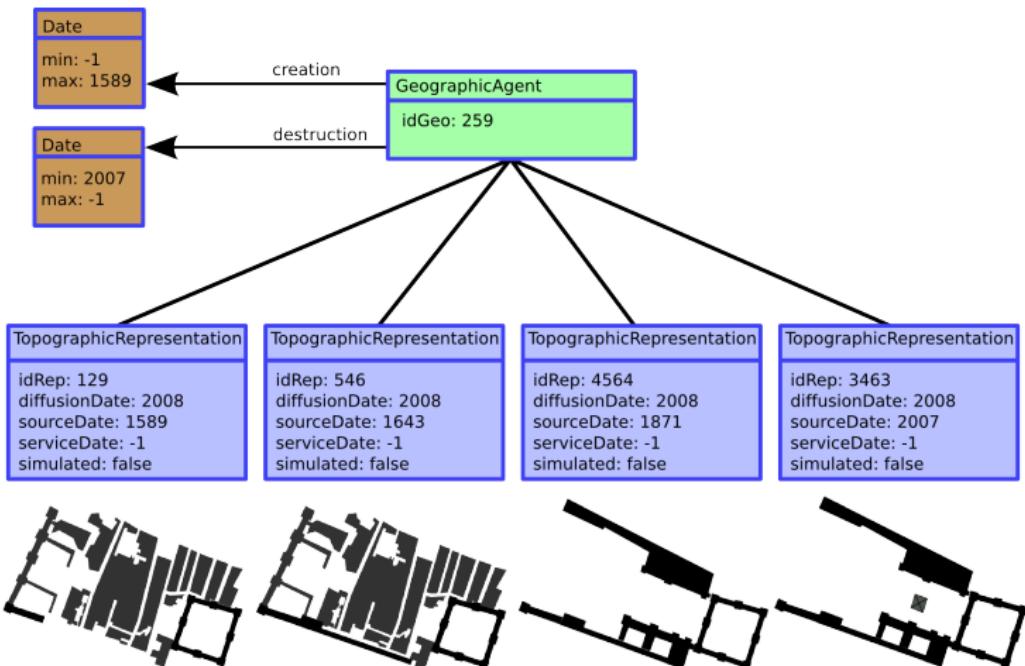
GeOpenSim Modules



GeOpenSim class diagram

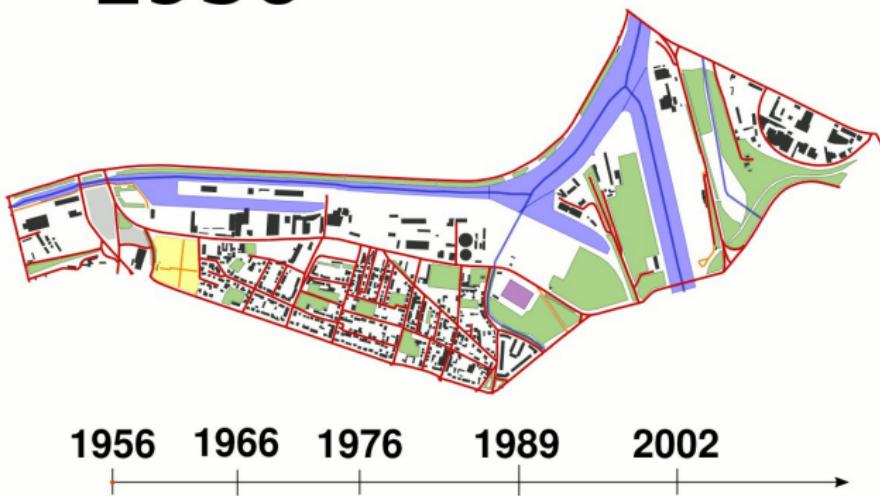


The Louvre as a geographic agent



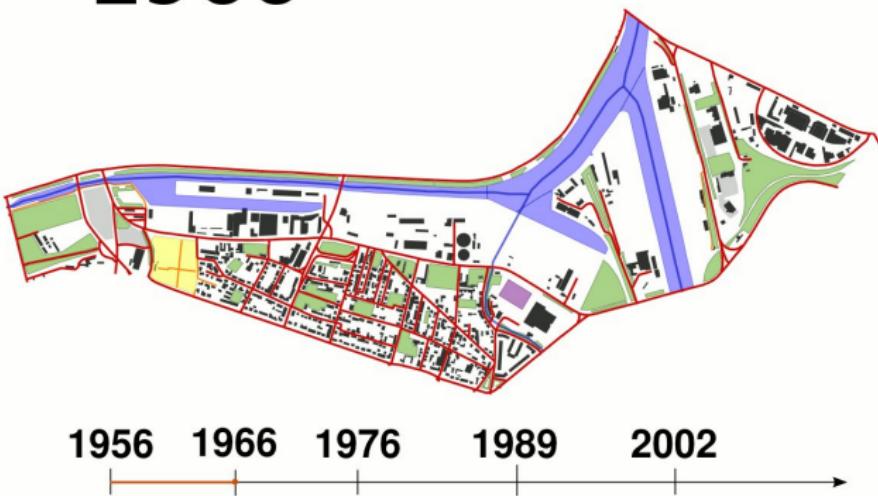
GeOpenSim Sample data

1956

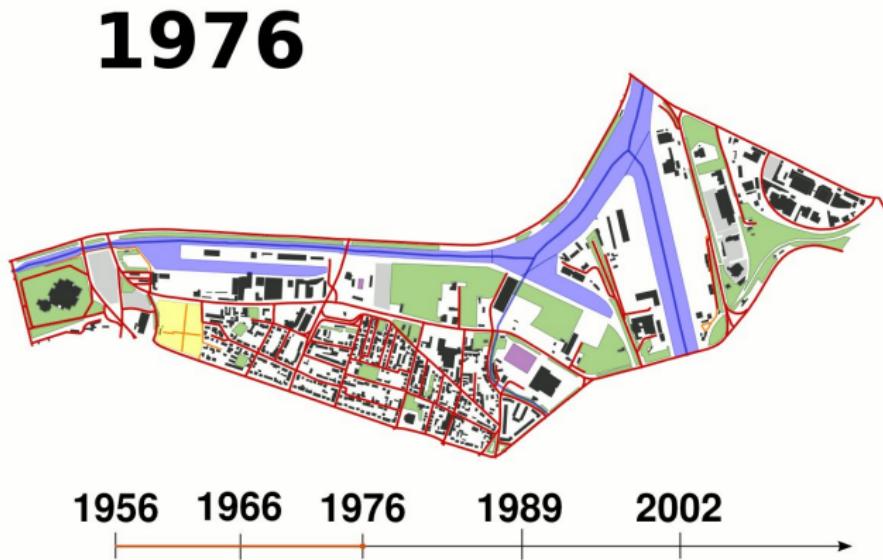


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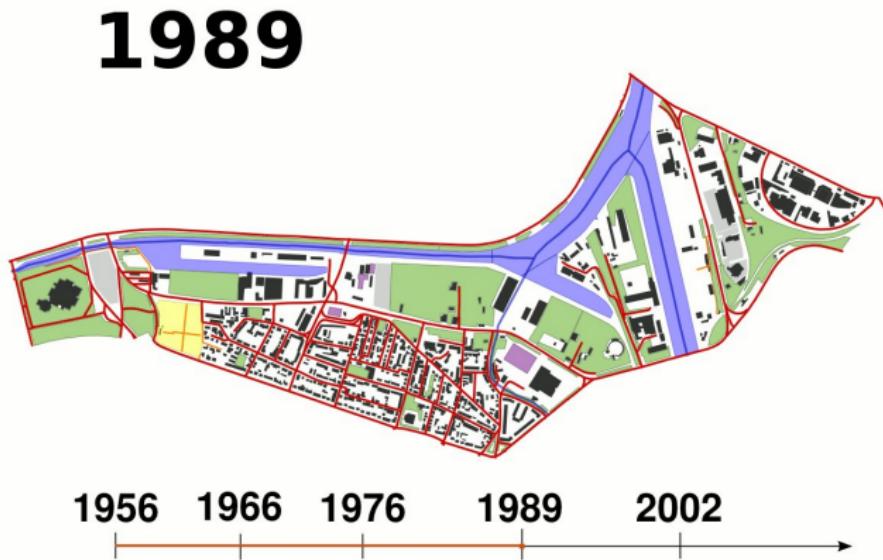
1966



GeOpenSim Sample data

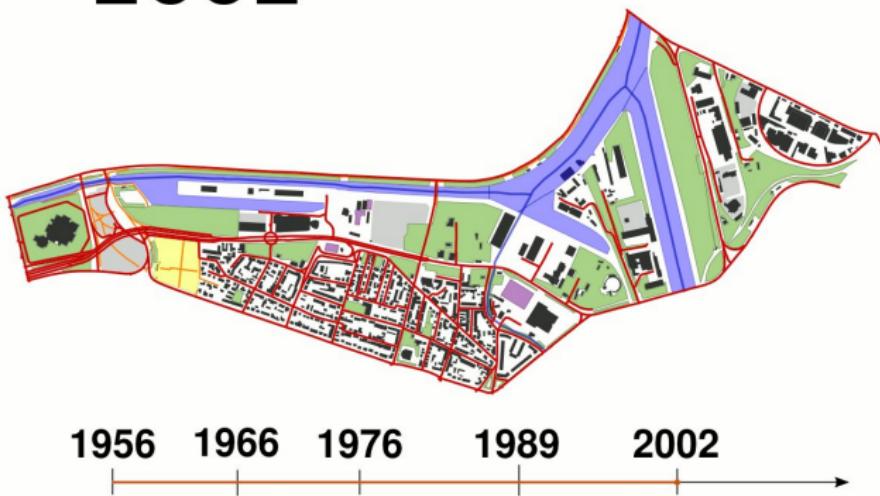


GeOpenSim Sample data

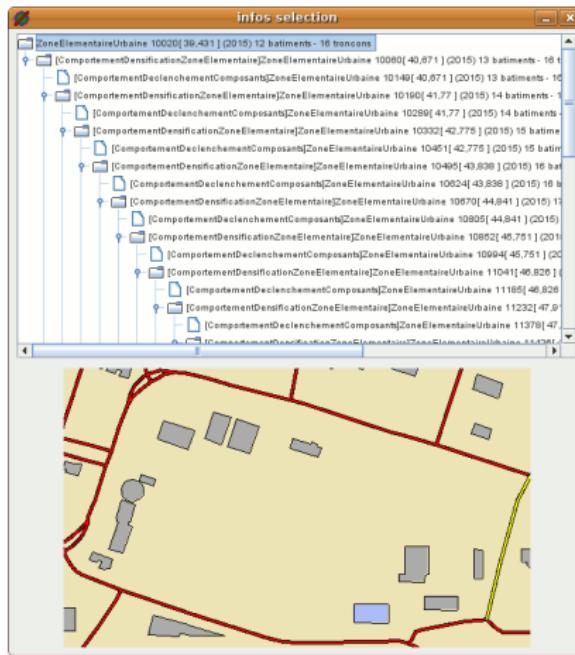


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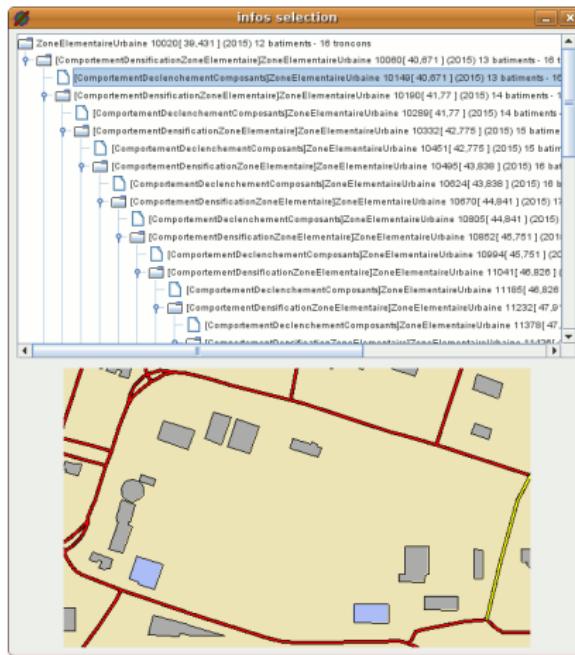
2002



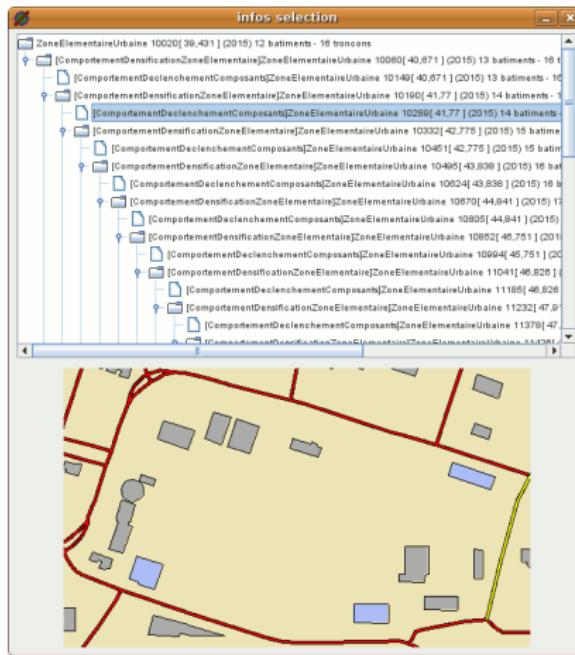
GeOpenSim tracking view



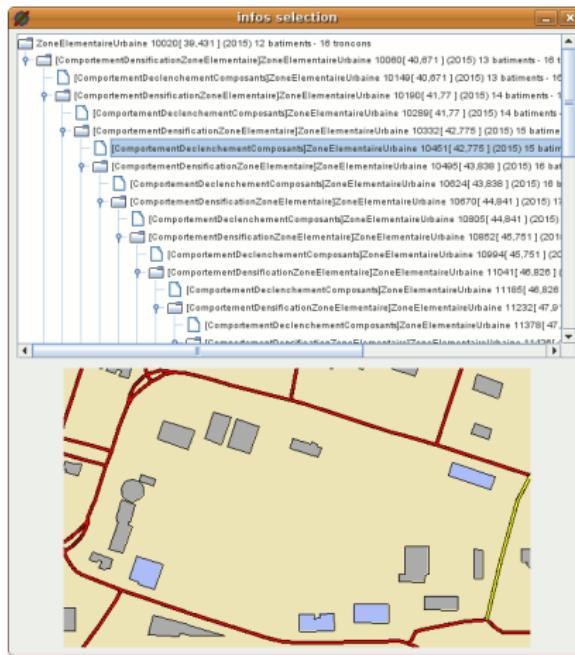
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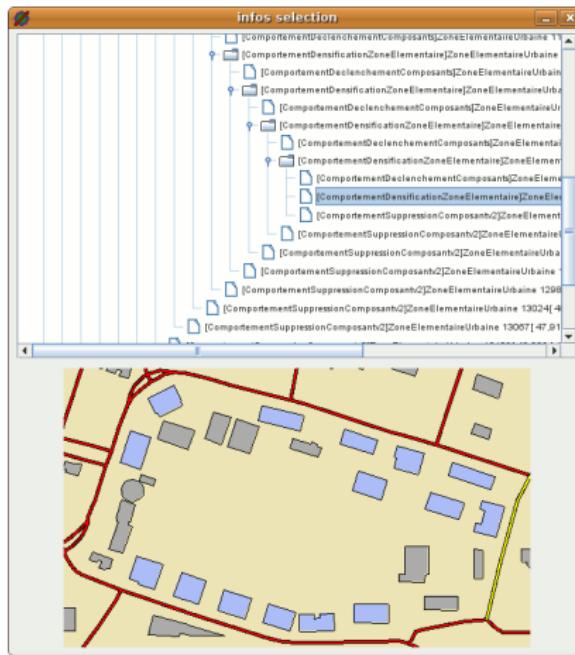
GeOpenSim tracking view



GeOpenSim tracking view



GeOpenSim tracking view



A constraint example

A constraint on urban blocks

$$100 * \left(1 - \frac{(density_{current} - density_{target})^2}{density_{target}^2}\right)$$

potential actions:

- make a new building
- make a new service road
- extend an existing service road
- etc.

An Agent's life

