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Clarity experimentations for cartographic generalisation in production

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1. Topographic maps series and vector databases production at IGN

Sixty years ago, IGN decided to produce different topographic map series at different scales: 1:25 000, 1:50 000 and 1:100 000. These series were produced using conventional mapping techniques, each providing a complete coverage of France. At the more detailed scale, 1:25 000, 40 years have been necessary to cover the whole of France (around 1800 sheets) with these drawing solutions. Six years ago, a new updating process was progressively introduced for these series to replace conventional mapping solutions by editing raster files.
In 1998, IGN decided to produce two vector geographic databases on the whole of France: BDCarto® with a resolution of 10 m and BDTopo® with a resolution of 1 m. BDCarto® was completed in 1992 and BDTopo® will be completed in 2006. These geographic databases are updated frequently. But, during many years, there was no link between topographic map series and geographic databases. These two different kinds of products were updated independently with different processes.
To reduce the production cost and to take advantage of geographic databases, IGN decided first to do some development efforts to be able to produce topographic maps series from geographic databases. In 1993, a new flow line was defined to derive a cartographic database and topographic maps at scale 1:25 000 from BDTopo®. This solution was possible because the resolution of BDTopo® (1m) corresponds to a 1:20 000 scale and so there is not a lot of generalisation problems to produce maps at scale 1:25 000. During 12 years, 400 sheets were produced with this flow line.
But it was still impossible to derive the 1:50 000 and 1:100 000 scale map series from vector geographic database and it was difficult and expensive to update maps with geographic database. Before introducing new cartographic flow line at IGN, it was essential to launch some important research efforts on generalisation and updating. In 1991, the COGIT laboratory started researches on these subjects and with the collaboration of many universities in the world a lot of progress has been made.

2. Carto2001 Project Experience

2.1 Aims

In 1999, after some important results obtained by the research on roads generalisation, it appeared at IGN that it was possible to develop a new flow line to produce Top100 series maps (at scale 1:100 000) from BDCarto®. So IGN decided to launch the Carto2001 Project. The aim of this project was to replace the TOP100 series with a new set of maps using BDCarto®. To reduce the costs of producing and updating this new series of maps significantly, it was essential to develop highly automated methods. The Carto2001 project had to provide new techniques for generalisation, label placement and map updating. It also had to introduce new production methods at IGN: working on a database covering the whole of France instead of separate sheets (thus avoiding the need to reprocess the overlapping areas between sheets) and using LAMPS2, new GIS at IGN, to enable multiple users to work on a shared database covering the whole of France.

2.2 Results

These new techniques were already presented in details at the ICA workshop on Map Generalisation and Multiple Representation and ICC Conference in 2003 (Jahard, 2003; Lemarié, 2003).The results for the first prototype were detailed last year at the ICA workshop on Map Generalisation and Multiple Representation at A Coruna (Lecordix, 2005).
For generalisation, the Agent solution was used specially for mountain roads generalisation (see

Figure 1 and 2) and beams algorithm (Bader, 2001) was used to solve overlapping problems.

Figure 1. Initial data BDCarto®

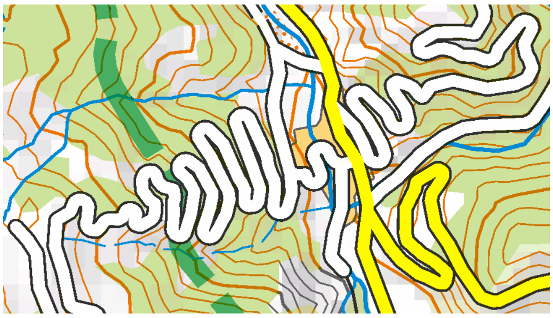

Figure 2. Data after generalisation with Agent prototype

Here is a summary of the main productivity gains: for the first edition of one sheet (91cm x 121 cm), the generalisation process required 150 hours (instead of 1200 hours with a full interactive process), the label placement required 160 hours (800 hours with a full interactive process) and the full process to produce first edition required 6 months (16 months with a full interactive process); to update the cartographic database (with a solution to propagate change stored in the geographic database to the cartographic database), the new technique allowed to reduce drastically the updating workload: 60 hours instead of 300 hours for editing the raster file.

This new flow line is now used by operators in production at IGN: in 2006, 8 operators are producing the first edition of 9 sheets. The production plan is confirmed and 30 sheets will be produced next years with 12 operators who will work simultaneously with LAMPS2.

2.3 Back Experience

Even if these results are very satisfying for IGN production to decrease the generalisation cost, it is important to underline some conclusions:

- All generalisation problems are not solved with the Carto2001 project. The project worked essentially on networks, especially on roads network. All difficult problems on building generalisation are absolutely not handled by the project Carto2001.
- To derive 1:50 000 scale map series from the vector geographic database BDTopo®, the generalisation of buildings must be solved. A lot of solutions for buildings generalisation are proposed by the COGIT research laboratory and implemented in LAMPS2 with Agent. It therefore seems possible to derive 1:50 000 scale map series.
- The first implementation of the Agent prototype in LAMPS2 was a very complex system that only experts were able to adapt and use for generalisation. To finalise the prototype only for roads and to be able to use it in production a lot of work was necessary. For buildings, IGN will have again to do a lot of development work on the Agent technology before the exploitation in production is possible.
- A part of the AGENT project philosophy was lost: the Agent prototype was not a generic system for automatic generalisation that each user would be able to adapt easily for his own needs with his own specification. This was due to some weakness of the initial implementation (which was only a research prototype) due to a lack of experience with the agent technology during its development. These weaknesses would be corrected before to launch a new project at IGN for 1:50 000 scale map series.

2.4 MAGNET collaboration and Clarity

Convinced by the Agent technology and its capabilities, four National Mapping Agencies (French Institut Géographique National, Danish Kort & MatrikelStyrelsen, Belgium Institut Géographique National and Ordnance Survey Great Britain) decided in 2002 to collaborate in the MAGNET consortium (Woodsford, 2003, Lecordix 2005) and to fund the development by Laser-Scan of a new

system based on the Agent technology, called Clarity.
Clarity had to correct three main weaknesses which were analysed with the first Agent prototype:

- The core of the Agent system was not clean, flexible and generic enough. These weaknesses meant that the core needed to be adapted for each new utilisation of the system, which was a difficult task.
- The Agent prototype had no interface to introduce parameters and tuning the system was definitely not user friendly.
- The agent concept with the possibility to extend easily the system with new constraints, measures, algorithms was lost in the Agent prototype.

In July 2003, the first version of Clarity software was provided to four NMAs and in October 2004 the final version was proposed.

3. New Base Map Project

3.1 Aims

In June 2004, a second cartographic project, called New Base Map Project, started at IGN with some resemblances to Carto2001 project, but with two important differences.
Its aim is to produce from the vector geographic database BDTopo® a cartographic database with multi-representation and to print 1:25000 and 1:50 000 map series. Label placement, printing and updating are not considered as problem anymore due to the Carto2001 experience. We hope again to work on a database covering the whole of France instead of separate sheets
A first important difference concerns the initial data which will not come from a single database: even if the data come mainly from BDTopo®, other databases and other different sources will be used; consequently some problems of data conflation between sources will occur. The update retrieval of the different sources and the propagation in the cartographic database will also need to be looked at.
A second important difference concerns the generalisation process. Even if overlapping problems for networks are still present, an important other problem must be solved to produce 1:50 000 maps: buildings generalisation. To solve all the generalisation problems, the project decided to use Clarity.

3.2 Buildings generalisation research

Buildings generalisation is an important subject of research and a lot of work and thesis have been published around the world and at the COGIT laboratory. In a development approach and to obtain results as soon as possible with the possible help of experts very close (Project and COGIT staff are in the same site), the New Base Map Project decided to use strategies and solutions proposed by the COGIT laboratory (Ruas, 1999; Regnauld, 1998; Boffet, 2001) and the AGENT project (Lamy,1999; Barrault, 2001). A very short description of buildings generalisation process with AGENT philosophy is presented here:

- Some urban structures are computed. For example: cities and urban blocks which are partitions of the cities by the networks.
- Cities and urban blocks are then characterised to improve generalisation. This characterisation allows distinguishing different kinds of blocks, for example: unitary blocks, suburban blocks, urban blocks, centre blocks, etc (Figure 3).
- Each type of block corresponds to a meso agent class that holds a specific generalisation process. For example, the generalisation sequence on a suburban block (Figure 4 a) is :
    - First, to remove buildings in order to make room in the blocks. In the AGENT philosophy, generalisation is lead by a set of constraints to satisfy. To remove buildings, we have to consider the density of the blocks, the number of buildings and the layout of the buildings (Figure 4 b).
    - Then, to generalise the shape of the buildings, in order to make them legible at the final scale: it's the micros generalisation (Figure 4 c).
    - Last, as buildings have been enlarged, they can overlap other features, so a displacement is performed (Figure 4 d).

The state retains by the process is the one that makes most constraints happy.

Figure 3. Creation and characterisation of urban structures.
Limits in red are big cities, in green rural cities.
Areas in different colours correspond to different kinds of urban blocks

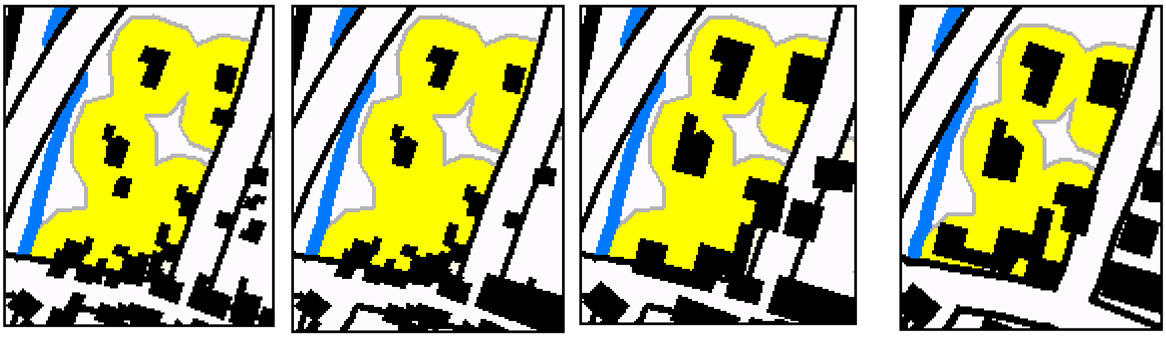

Figure 4. Agent generalisation sequence on a suburban block
a) Initial data b) After elimination c) After micro generalisation d) After displacement

3.3 Clarity experience on buildings

The buildings generalisation process is maybe one of the most complex. So it is very interesting to use this process to test Clarity and to examine the advantages which are provided by this new version of Agent. The New Base Map Project has therefore decided to migrate first the buildings generalisation processes from the Agent prototype in LAMPS2 to Clarity.

This decision took into account an important factor: with the Agent prototype in LAMSP2, we had some experiences and we observed that we were not able to produce a whole of map. During the project Carto2001 and after the AGENT project, an important effort was made by Laser-Scan on Agent to be able to generalise all roads and to handle the process on a whole of map. It was difficult because the core of the Agent prototype was not clean, flexible and generic enough and there was no interface. So, for buildings, we knew that we would have the same problems. By using Clarity, we hope to have fewer problems to tune the system for all buildings and to be able to generalise a whole map with all buildings. The job was done by Jenny Trévisan who had some experience on the Agent

prototype in LAMPS2 and Jean-Marc Le Gallic who had no experience on Agent.
The main positive conclusions on the migration to Clarity:

- Clarity provides a very friendly user interface and so it is very easy to introduce and understand a complete Agent generalisation process (Figure 5).
- The tuning of the generalisation process in Clarity is much easier due to the interface.
- Clarity allows using LULL (language in LAMPS2) and JAVA. So it is possible to use old algorithms developed in LAMPS2 and to introduce some codes developed in JAVA in other software's.
- For micro generalisation on buildings, Clarity is more efficient (the code of the Agent core has been cleaned up) and it is possible to launch the micro agent process on buildings without any problem on the whole of map (but so buildings are generalised one by one and contextual generalisation is not taken into account).

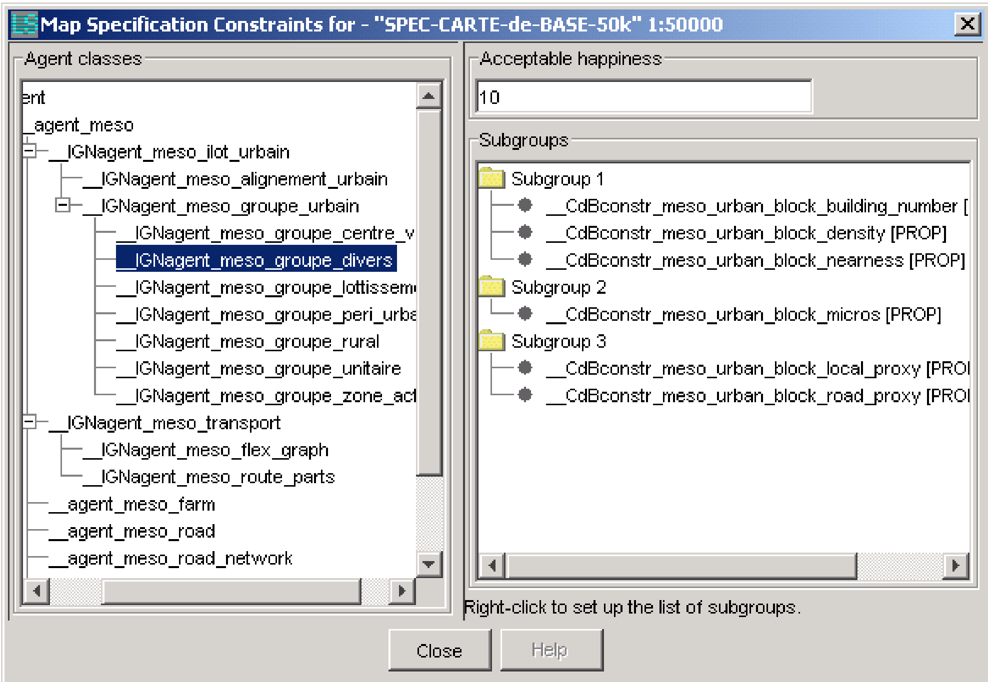

Figure 5. Clarity interface to introduce Agent generalisation sequence on a suburban block

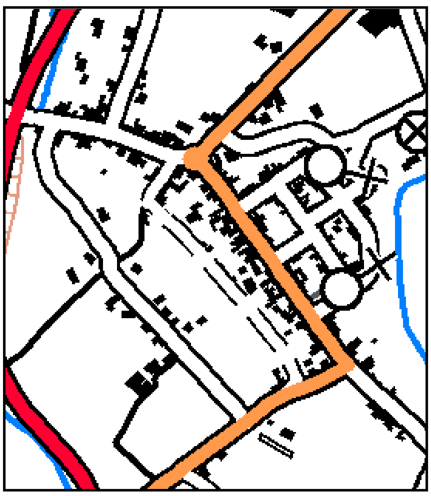

Figure 6. Initial data BDTopo®

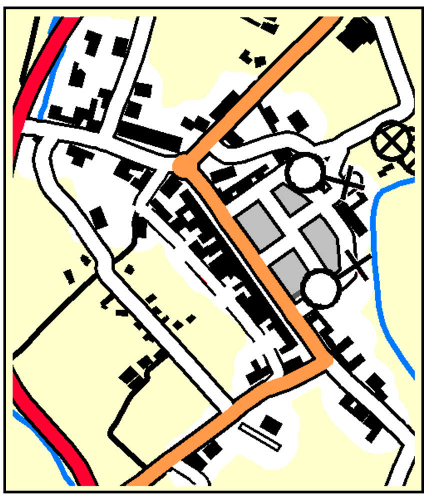

Figure 7. First buildings generalisation results obtained with Clarity

An example of a complete Agent-based generalisation process on buildings with Clarity is presented in Figure 6 and Figure 7.
A lot of improvements were observed with Clarity, but there is a problem of memory leak on meso agents and so it is not possible to launch the complete generalisation process on a whole of map. This problem of memory will have to be solved by Laser-Scan for the next version.

3.4 Clarity experience on roads

To continue to experiment Clarity, another test was launched by the New Base Map Project: the replication in Clartiy of the generalisation process on roads that the Carto2001 Project had developed in LAMPS2 with Agent. The first aim of this test was to check that generalisation results are similar. The second aim was to compare the difficulty to tune Clarity in comparison with the solution implemented in LAMPS2 with Agent. For this second test, conclusions are made from a point of view of a user or an expert in generalisation, but not an expert of the Agent technology.
It is important to underline that for such users, Clarity provides two main additional possibilities in comparison to the Agent prototype:

- Interface: Java interfaces are provided to satisfy a user or an expert. The user can setup the parameters for the generalisation process, save and load parameters to and from XML files. The expert can modify constraints and agents. All the tunings are very easy to make.
- Extensibility: although predefined constraints, measures and generalisation algorithms are implemented and usable immediately in Clarity, the system offers the possibility to integrate easily new knowledge. New constraints, measures and algorithms can be added in LULL (proprietary language of Laser-Scan) or in Java. This evolutionary approach of Clarity allows one to carry on with new research or to adapt the system to specific generalisation specifications. This option was used to implement our generalisation process for mountain roads.

These improvements made Clarity easier and quicker to use and tune, than the Agent prototype. So, during a short internship - two months -, the student Loïc Gondol was able to learn to use Clarity and reproduce easily the process developed in LAMPS2 with Agent to generalise mountain roads. During the Carto2001 Project, using Agent in LAMPS2, this required many months.
Roads generalisation obtained with Agent and Clarity are very similar for most of the roads (Figure 8). It is not really a surprise because constraints, measures, algorithms introduced by the user in Agent and Clarity are the same.

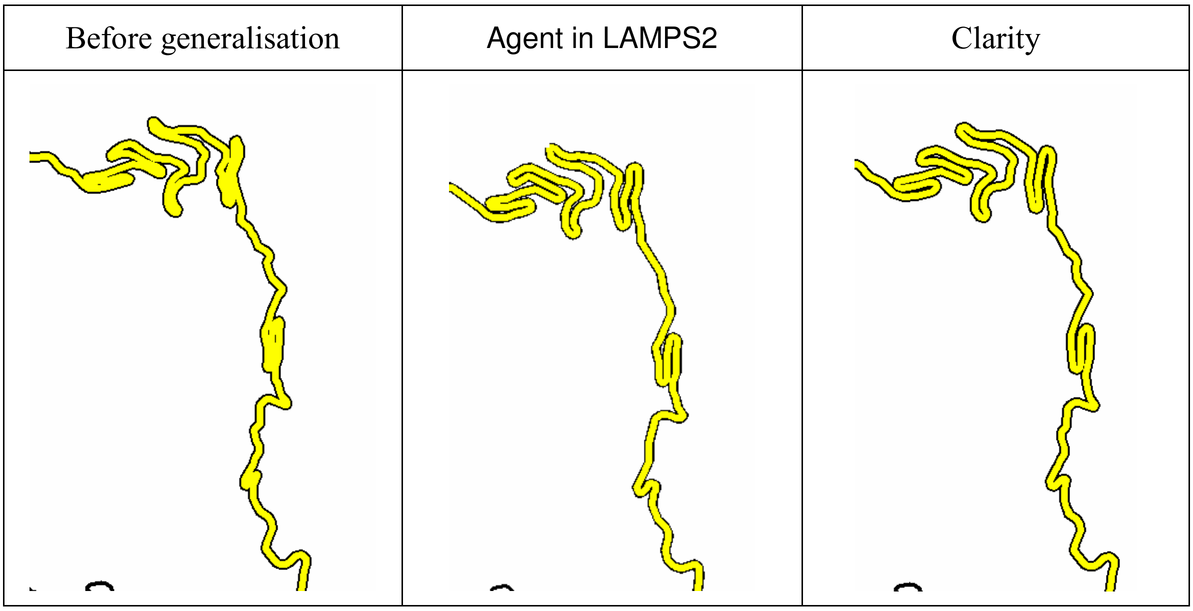

Figure 8. Initial data BDCarto® and generalisation with Agent in LAMPS2 and Clarity

For some specific cases, the Clarity's generalised road is not exactly the same than the Agent prototype because one option - to advice against plans - present in the core of the Agent system in LAMPS2 is not introduced in the Clarity version. This option will have to be reintroduced in a next Clarity version.
Another problem concerns the diffusion of the displacement for roads extremities: it can not be propagated by the road network. There was no problem with the Agent prototype. It is a bug in one algorithm which must be corrected by Laser-Scan in a next version of Clarity.
The problem with memory leak with meso agent that we already discovered with buildings is observed too for roads and so it is impossible to launch the process on a whole map at this moment. This problem will have to be solved by Laser-Scan for the next version.

4. Conclusion

Even if the first tests with Clarity are not fully satisfying, in particularly to generalise a whole of map, it is possible to observe that the main problems detected on the Agent prototype are modified: with a better interface and more flexibility, Clarity can be used and tuned more easily and quickly than the Agent prototype. Some improvements will be done in Clarity by Laser-Scan during the summer 2006 to provide a new version in October 2006 that we hope will satisfy the NMA's requirement for production.
After a first new flow line with Agent in LAMPS2 to produce Top100 series maps (at 1:100 000) from BDCarto®, IGN hope to be able to introduce with Clarity another flow line to produce Top50 series maps (at 1: 50 000) with Agent technology. This new solution might be presented next year at the 10th workshop on Generalisation and Multiple Representation, at Moscow.

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