FROM DLM TO MULTI-REPRESENTATION DCM - MODELLING AND APPLICATION ON BUILDINGS -

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ABSTRACT

This paper proposes a proper modelling to derive a multi-representation DCM for 1:25000 and 1:50000 scaled maps from IGN's DLM, the BDTopo®. In this study, we focus on the modelling of buildings.
The data schema proposed, based on the initial DLM schema, offers the versatility to set either cartographic level free from the other: 25k objects live their own cartographic life (symbolisation and generalisation) independently from 50k objects. However, each cartographic object always knows where it comes from because of a link to a reference level, which stores the initial geographic states of all objects. This schema makes automated updates easier.
In order to improve automated cartographic generalisation and updates of this DCM, we enrich this schema with a meso level of complex geographic phenomena. They allow us to describe the geographic environment of a specific object. In the case of buildings, the most common phenomenon is the urban block. This study shows how to do this enrichment while remaining consistent with the multi-representation philosophy.

1. INTRODUCTION

1.1 Some definitions…

When one wish to produce a map from a Digital Landscape Model (**DLM**), we have to simplify the topographic objects for them to be readable at the cartographic scale. This simplification of the information is called cartographic generalisation.
The data from the initial DLM are therefore modified to produce the map, and in this way we obtain a new digital model, no more topographic but cartographic: a **DCM**. A DCM fits with the cartographic specifications of the map to produce: scale, content and symbolisation.

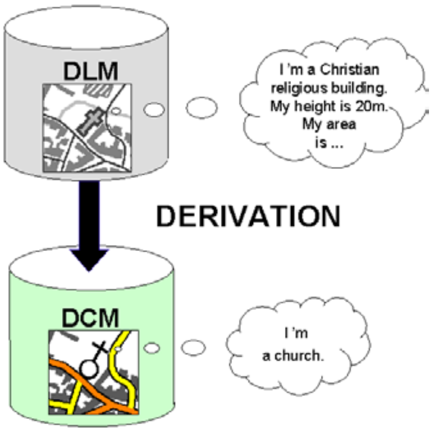


Figure 1 - Derivation of a DCM from a DLM

The **derivation of a DCM from a DLM** is here defined as all the operations needed to produce the final DCM from the DLM: modelling of the DCM, filtering of data to match the intended content of the map, cartographic symbolisation and generalisation of the data (see figure 1).

1.2 What we intend to do

As input data, we use the IGN's topographic database, the BDTopo®, which is a Digital Topographic Model, i.e. a topographic DLM. It has metric resolution, topological data, and single identifiers on each object. We intend to produce two collections of maps: one at the 1:25000 scale (25k), and one at the 1:50000 scale (50k). In our case, the way to derive the 25k from the DLM is quite similar to the derivation of the 50k. The two collections of maps have actually the same content specifications, except for the symbolisation and the generalisation.
Instead of planning separated production lines for the 25k and the 50k, we try here to build a multi-representation DCM. This database shall be able to:
(1) deal with the multi-representation 25k and 50k
(2) take the constraints to set automated generalisation process into account
(3) make automated updates easier.

Here after, we will call this multi-representation database the DCM 25k-50k (figure 2).

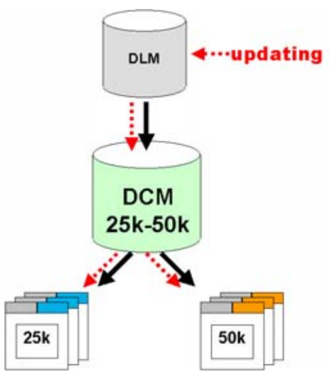


Figure 2 - Multi-Representation DCM 25k-50k

1.3 Searching process

The content specifications as well as the legends of both 25k and 50k collections are supposed to be known: they will help us to build the DCM 25k-50k. This paper mainly deals with the modelling aspect of the DCM. We expect to propose a data schema suitable for solving the cartographic problems (symbolisation and generalisation), allowing an efficient updates propagation, without being too different from the initial DLM schema.

We focus particularly on the modelling of buildings, which is one of the trickiest themes as regards generalisation for these two scales. But the approach used here can be extended to other themes.

First, we will see how to build a data schema for the DCM 25k-50k, and next, we will explain how to enrich this schema in order to make generalisation and updates easier.

2. BUILDING A SCHEMA FOR THE DCM 25K-50K

Let us see how to build a data schema suitable for the needs of our DCM.

2.1 Starting point : the DLM

Throughout this section, we follow the derivation of buildings from the BDTopo®. We assume that all the buildings such as ordinary buildings, town halls, churches or silos and so on, are gathered together in a single surfacic class called BUILDING. This class holds several specific fields (figure 3):

- The ID field holds a single identifier for each building.
- The SOURCE field tells how the building was digitised.
- The NATURE and CATEGORY fields hold the semantic differentiation between buildings. The CATEGORY can be "administrative", "industrial", "agricultural", "commercial", "religious", "sports", "transport" or "other". The NATURE can be: "air terminal", "triumphal arch", "industrial building", "commercial building", "agricultural building", "religious building", "sports building", "chapel", "castle", "church", "fort", "station", "town hall"…
- The HEIGHT, Z_MAX and Z_MIN fields inform us about the altimetric position of the buildings.

Figure 3 - BUILDING class of the DLM

2.2 What we have to model…

To build a proper modelling of one DCM, there are several possibilities, each one depending on the aim of this DCM. Let us see how we did our DCM 25k-50k.

… for the updating

The ID field must be kept as a direct link between the DLM and the DCM in order to optimise the updating.

… for the symbolisation

When reading the cartographic specifications of a specific map collection, we realize that the symbolisation of a geographic object may depend as well on its semantic fields as on its geometry. As shown in figure 4, the choice of symbolisation is based on an analysis on the geographic object. The symbolisation can even change the geometric nature of the geographic object: because of the symbolisation, surfacic geographic objects can be punctualised as point cartographic objects.

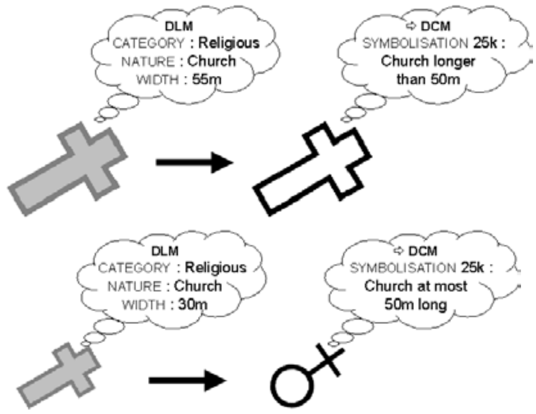


Figure 4 - Geometric and semantic analysis to symbolise a church. Symbolisation can change the geometric nature of the object.

In the DCM, we shall therefore only keep the DLM fields necessary to compute the symbolisation, namely CATEGORY and NATURE: a selection of the DLM fields is required. This symbolisation information is of the utmost importance and must also be stored in the DCM. Finally, the cartographic geometry must be stored as well.

… for the multi-representation

The symbolisation may be different from one scale to another as shown in figure 5. The DCM has to take these multi-representation differences into account.

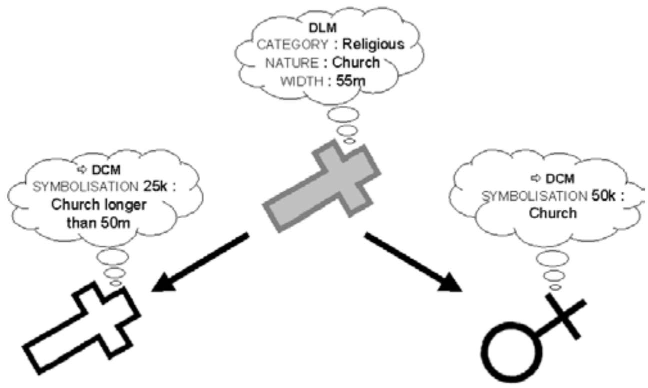


Figure 5 - Multi-representation

… for the cartography

Some specific cartographic fields must also be added to the DCM. For instance, in figure 6, the symbol has to be -82 degree rotated in order to simulate the geographic orientation of the church. This value can be stored in a specific field.

Figure 6 - Symbol orientation

… for the generalisation

The modelling must also be accurate to allow an easy generalisation.
Concerning buildings generalisation, surfacic buildings must be quickly identifiable in order to proceed their individual generalisation (generalisation of their shape). During contextual generalisation, buildings can be displaced or removed but important buildings must be preserved (figure 7).

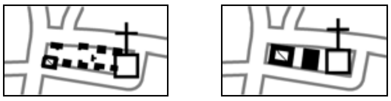


Figure 7 - Urban block generalisation for the 50k: important buildings are preserved.

All these rules have an influence on the modelling.

2.3 Data schema proposition

We propose here a data schema for the DCM 25k-50k, taking into account all the needs we have identified above. The language to describe the schema is UML.

General principle

The schema we propose is based on the initial DLM schema: first of all, we create some reference classes (named with _REF suffix) which are copies of the DLM classes filtered of the fields that are not useful for cartography and updating.

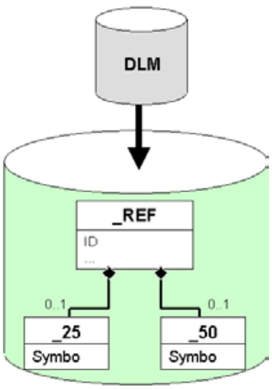


Figure 8 - General principle of the multi-representation schema in UML.

Each reference class is linked with two independent cartographic classes, one for the 25k and one for the 50k. These two classes, whose names have _25 and _50 suffixes, hold purely cartographic fields such as symbolisation (see figure 8).
One reference object is therefore linked with one 25k object and one 50k object. One object from the DLM corresponds to three objects in the DCM 25k-50k.
Instead of managing three different classes representing the same geographic phenomenon, we could have decided to create only one class with several geometries (one topographic and two cartographic). But, as most GIS do not provide multi-geometry capacities with efficiency, we have chosen this modelling based on three classes.

Case of buildings classes

The data schema for buildings is presented in figure 9.
The BUILDING_25 class is divided into :
- one ORDINARY_BUILDING_25 class
- one IMPORTANT_BUILDING_25 class

This splitting allows us to bring up the semantic differences that are important in generalisation.
The IMPORTANT_BUILDING_25 class is itself divided into :
- one IMPORTANT_PONC_BUILDING_25 class which stores punctual buildings.
- one IMPORTANT_SURF_BUILDING_25 class which stores surfacic buildings.

This differentiation gives a direct access to the different cartographic geometries.
The same philosophy is used for the BUILDING_50 class.

In the cartographic classes, the objects can be removed unscrupulously at any time of the generalisation process because they can always be created again from the reference objects.

2.4 Results

Practically, this schema has been implemented with the Lamps2 GIS, and the creation of the cartographic objects from the reference objects has also been automated. **Precoding** is the name chosen for this operation of filling up the cartographic levels. The figure 10 shows that precoding is operational not only for buildings, but also for all the geographic objects from the DLM to be found in our 25k and 50k maps.

Modelling and symbolisation of the cartographic data are now completed. We are ready for the next step: data generalisation. This operation requires a preliminary enrichment of the schema.

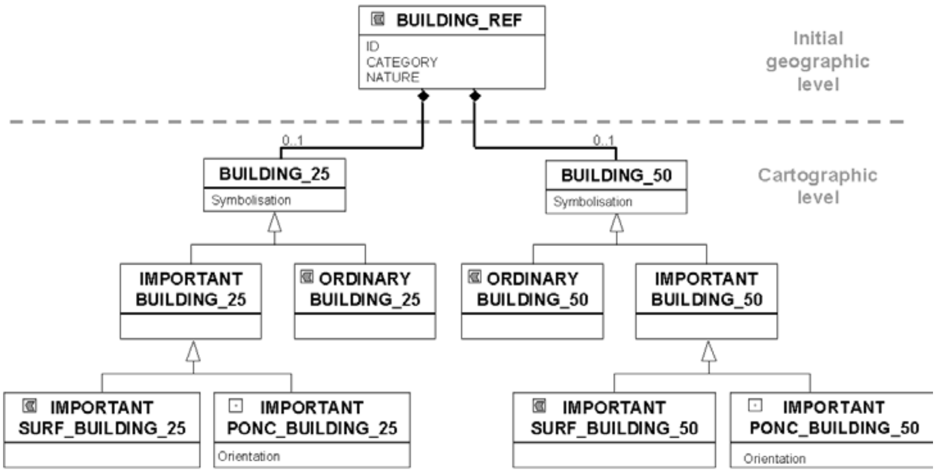


Figure 9 - DCM 25k-50k: Buildings multi-representation schema in UML

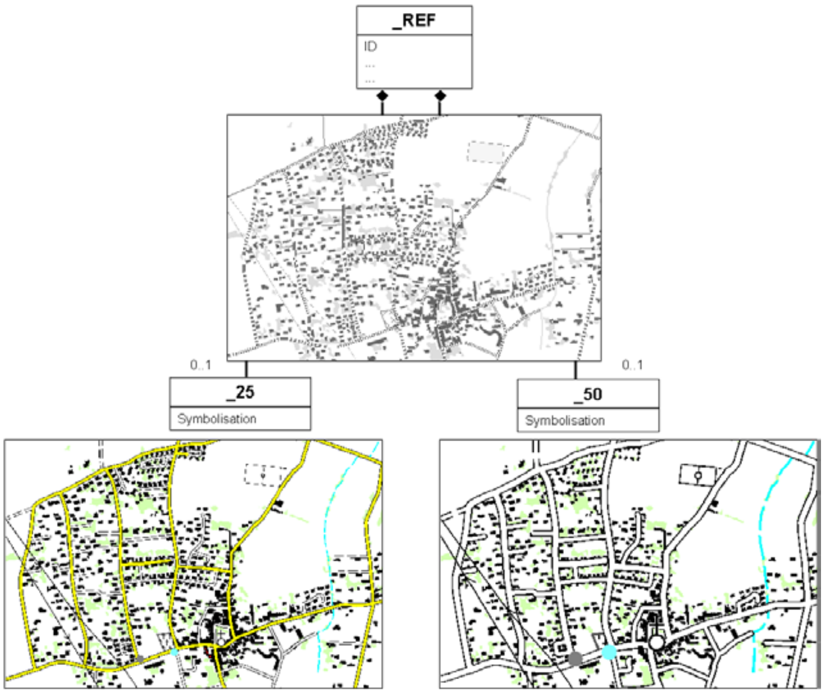


Figure 10 - Precoding of the DCM 25k-50k, with network removal concerning the 50k (Application with Lamps2)

3. SCHEMA ENRICHMENT TO MAKE GENERALISATION AND UPDATING EASIER

After precoding, buildings within each cartographic level are independent: they can be displaced, removed during the generalisation process, while knowing they can be created again from the reference level. In order to optimise their contextual generalisation, it is usefull to enrich the initial data with special structures allowing the description of the environment of each object.

3.1 Complex geographic phenomena

These structures are not haphazard and correspond to geographic phenomena that are not modelled in the initial DLM, even though map readers perceive them: a succession of curves on a road, a city, an industrial estate, and so on. They gathered together a certain number of existing geographic objects: a succession of curves consists of road sections, a city consists of buildings and streets (figure 11).

Figure 11 - City border created from the reference buildings.

These complex phenomena are also known as ***meso*** structures in the generalisation literature [RUAS 99].
The data schema is therefore enriched with new classes of complex phenomena (figure 12), instanciated automatically from special processing on the objects of the reference classes.

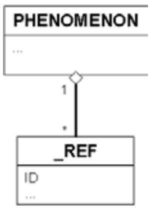
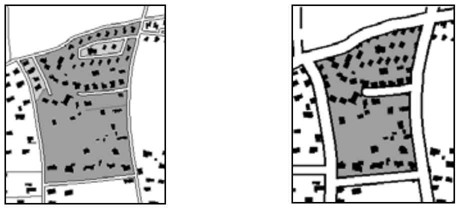


Figure 12 - Composition link between the reference classes and the new classes of geographic phenomena.

Complex geographic phenomena must be preserved during the generalisation process and will help to trigger and guide generalisation operations.

3.2 Example with urban blocks

To generalise buildings, the phenomenon most used is urban block. It is for instance the case in the AGENT generalisation prototype (see [DUCHENE and RUAS 01] or [AGENT 04]). Let us see how to enrich our previous schema with this particular feature.
We create three new classes in the schema:
(1) the URBAN_BLOCK_REF class contains the real urban blocks, i.e. urban blocks topologically deduced from the networks and buildings of the reference classes. This class has a 1:n composition link towards the BUILDING_REF class.
(2) the URBAN_BLOCK_25 class, whose objects are deduced from the URBAN_BLOCK_REF class objects. One URBAN_BLOCK_REF object is linked to one single URBAN_BLOCK_25 object (the reverse is false due to network generalisation).
(3) the URBAN_BLOCK_50 class, whose objects are deduced from the URBAN_BLOCK_REF class objects. One URBAN_BLOCK_REF object is linked to one single URBAN_BLOCK_50 object. The reverse is false due to network generalisation (see figure 13).



Reference data *50k data with network generalisation only.*

Figure 13 - Three reference urban blocks correspond to one single 50k urban block due to network generalisation.

The enriched schema for buildings is described in figure 14. Three levels can be noticed:
(1) the initial geographic level is quite similar (though simplified) to the initial DLM schema
(2) the additional geographic level contains the complex phenomena
(3) the cartographic level.

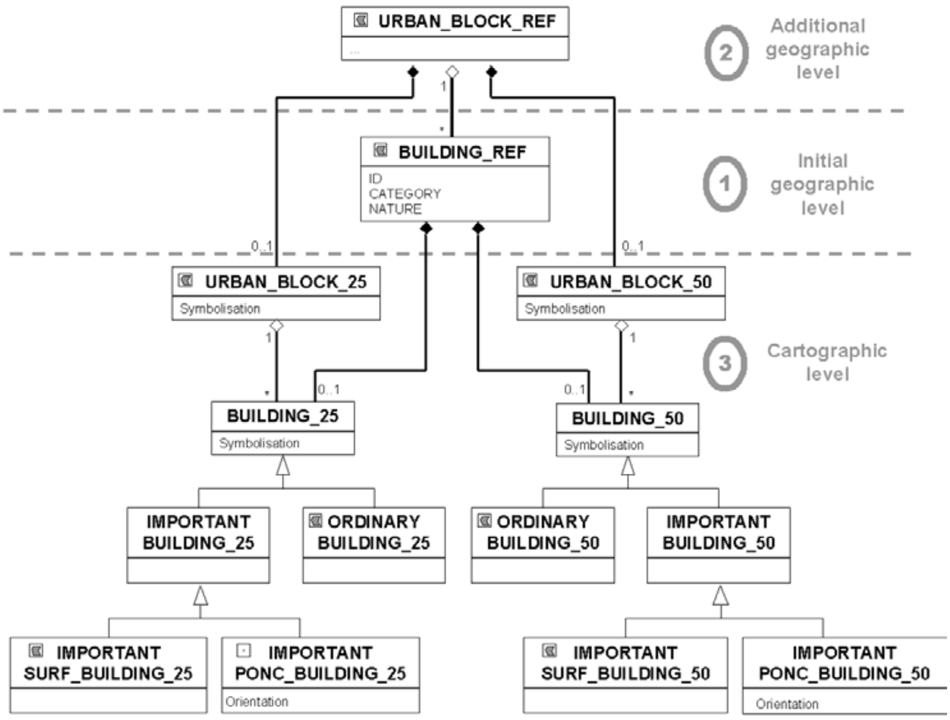


*Figure 14 - DCM 25k-50k: **Enriched** buildings multi-representation schema (UML)*

[GAFFURI and TREVISAN 04] give more details on the enrichment of a DCM schema with urban structures such as blocks, groups and alignments, in order to improve the generalisation process.

3.3 Using complex phenomena for the updating

As seen above, the DCM 25k-50k is built to allow a direct identification of the updated objects by means of the ID field and of the composition links between reference objects and cartographic objects.

But the update of one particular geographic object may constrain us to redraw its surrounding objects because of the cartographic symbols. The complex phenomena can intervene on this special point: triggering again the generalisation process in some places where the updating of one object interferes with the surrounding objects.

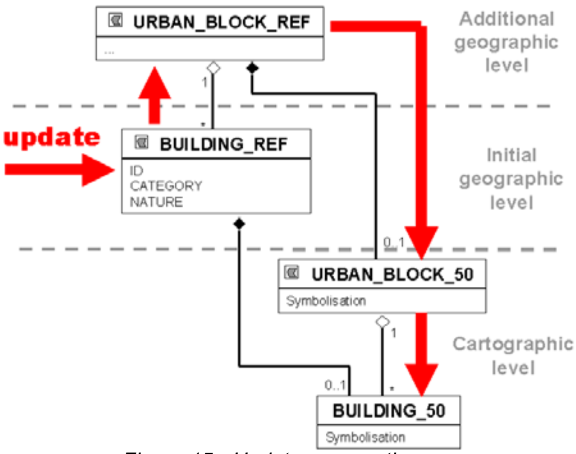


Figure 15 - Update propagation.

In most cases, the updating of one building (such as creation, removal, semantic change, enlargement or displacement), will trigger the generalisation process on the affected urban block. The propagation process is described in figure 15: the updated reference building looks for the urban block it's in. Then this urban block asks its corresponding cartographic blocks for triggering their generalisation again on their own buildings: the actual cartographic buildings are removed from the block and new ones are created from the reference ones (that are already updated), before the generalisation process is again triggered.

Complex phenomena are here used as intermediate objects to trigger the local cartography of the updated DCM.

4. CONCLUSION

We have proposed in this paper a proper modelling to derive a multi-representation DCM with 1:25000 and 1:50000 scales from IGN's topographic DLM, the BDTopo®. Our data schema, based on the initial DLM schema, offers the versatility to set either cartographic level free from the other: 25k objects live their own cartographic life (symbolisation and generalisation) independently from 50k objects. However, each cartographic object always knows where it comes from because of a link to a reference level, which stores the initial geographic states of all objects. This schema remains consistent with an updating process.

In order to improve cartographic generalisation and updates of this DCM, we have also enriched this schema with a meso level of complex geographic phenomena. These phenomena allow us to describe the geographic environment of a specific object, and eventually make the triggering of generalisation and updating process easier. In the case of buildings, the most common phenomenon is the urban block. We have showed how to do this enrichment while remaining consistent with the multi-representation philosophy.

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