ABSTRACT
We use a multi-agent approach to automatically perform cartographic generalisation, a task of the cartography domain that aims to simplify a digital map in order to produce another digital map with less details. Our agents are geographical objects such as houses, roads, rivers, etc. The agents interact so that each of them finds a new place and geometric representation that fits to the final map requirements. The principles of our approach are described here and some preliminary results are shown.

Categories and Subject Descriptors
I.2.11 [Artificial Intelligence]: Distributed Artificial Intelligence - Coherence and coordination; Multiagent systems; I.2.1 [Artificial Intelligence]: Applications and Expert Systems – Cartography.

General Terms
Algorithms, Experimentation.

Keywords
Multi-Agent Systems, Cartography, Cartographic generalisation, Resolution of spatialised problem, Situated agents, Conversation protocols, Representation of the spatial environment, GIS.

1. CONTEXT AND OBJECTIVES
We work on the automation of a complex task of the digital cartography domain: the cartographic generalisation of vector geographical databases. In a vector geographical database, objects of the real world (houses, roads, rivers, etc) are represented as points, lines or polygons (Figure 1a). Producing a map from a geographic database is not immediate if the content of the database is more detailed than the content of the intended map (Figure 1). In this case, the geographic database is modified by cartographic generalisation into a 'cartographic database' fitting to the map requirements [6]: the geographic objects are enlarged, simplified, displaced, or eliminated. This operation is performed using a geographic information system (GIS), that enables to handle, edit and display with cartographic symbols the content of a geographic database.

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share a relational constraint with it. The agent maintains a representation of the relational constraints it shares with its neighbours. To build this representation we introduce the concept of 'constrained zones': a relational constraint results, for each of the two implied agents, in a zone of the space on which the agent should avoid to encroach, called 'constrained zone'. E.g. for a building, a non-overlap constraint with a road prevents the building to encroach on the area limited by the road symbol. Each agent stores and updates its constrained zones resulting from all of its relational constraints. It then uses them to choose at any time the best possible position (the one that satisfies its constraints as well as possible).

2.2 Agents dialog with their neighbours
To decide how to act in order to solve a relational conflict, an agent needs to gather information about itself (its state, what it can do or not), but also about the other agent involved in the conflict. In some cases, it is not able to compute all the information itself and needs to get it from the other agent. This is why our agents need to communicate with their neighbours. Figure 2 illustrates this. The road agent which is a dead-end (light grey) can compute its symbol overlap with the building agent (black). The building agent can compute its proximity with the dark grey road. In order to undertake the right action, the dead-end agent needs to know that the building is stuck. Otherwise, it should wait for the building to move away, because it is a cartographic rule that, a priori, moving a building has less consequences than moving a road. The agents need to dialog so that the required information can be transferred.

The communication system must enable our agents to begin an action, interrupt this action to send a message to another agent, interpret a received message, and go on with its action according to the received messages. For that, we use pre-recorded interaction protocols (or 'dialog scenarios') designed for binary communication, that indicate how to act and how to answer when receiving a given message. The messages exchanged are based on the speech act framework [5]. The dialog protocols are modelled in the system as finite state machines (FSM), as proposed in [1] and [3] section 6.3.

2.3 Scheduling
The agents are activated one after another by a central scheduler. Several strategies of activation are currently tested. At the time being, one of the more satisfying is to trigger first the agent that has received the last message.

During its activation, an agent chooses at any time the next action it should perform thanks to a dedicated choice mechanism. These actions can be: handle a received message asking to do something, apply a transformation to itself in order to better satisfy a constraint, initiate a dialog with a neighbour.

3. PRELIMINARY RESULTS
The system has been implemented on the Geographic Information System LAMPS2 (from Laser-Scan Ltd), which is object oriented. Figure 3 shows preliminary results. The data used here are extracted from rural areas of the geographic database BDTopo®, the 1m resolution database of the French National Mapping Agency. The aim is to produce topographic maps at scale 1:25000 (the intended scale is a parameter of the system). Only road and building objects are considered. The considered constraints are non-overlap of symbols, proximity (that imposes a minimum distance between symbols) and topology, that prevents a building from "jumping over a road". Moreover, the buildings are able to perform individual generalisation because we reuse results stemming from [2]. The zone of Figure 3 contains 44 agents (10 roads and 34 buildings). Picture (a) shows the initial state, where the overlap conflicts between roads and buildings clearly appear. Picture (b) shows the final state: the buildings have performed individual generalisation (by enlarging or simplifying themselves), and the system has solved most of the overlap conflicts.

![Figure 3. Preliminary cartographic results](image)

4. REFERENCES