



Martijn Mes

Sorting out the 'logistics of baking cookies': an industrial bakery presented Martijn Mes with an ideal testing ground for a so-called multi-agent approach. The next step will be to use these intelligent agents to regulate international goods transport by road, reducing the number of empty trucks in transit.

## Coping with uncertainty in transport planning

"This bakery's decision to employ a multi-agent system is unusual. For example, they use Automatic Guided Vehicles (AGVs), rather than the usual pipelines, to collect ingredients together, to prepare the dough, and to transport it to the production lines. The AGVs run around the site with no restrictions. This is truly innovative, and I had hardly expected my recommendations to be implemented so rapidly." Multi-agent systems consist of a group of intelligent and autonomous software programs, or agents, which negotiate with each other in order to achieve their individual and overall objectives.

"In a bakery of this kind you can already see that you need agents with foresight. The simplest kind of agent is inadequate: it is a simple piece of software that takes a local decision and performs its local task as well as possible. But if the dough starts to rise while you are transporting it, you have a limited time in which to deliver it, but you also have to take other processes into consideration. Sometimes it might be better to wait a little rather than loading the dough immediately. The tasks can be divided by means of agents and virtual auctions. Each AGV is then an agent, as are the ingredient silos, the mixers and the production lines. For example, the production line could initiate an auction: 'I want dough'. The AGVs determine, with foresight, how much time a task will take them, and therefore what 'price' they should charge. Conversely, the AGVs could initiate the auction. I presented the bakery

with several alternatives and demonstrated with simulations the arrangement that would work best in their situation."

"You can learn a great deal in this closed system in industry that is relevant to large-scale logistics planning, and for goods transport by road. At first sight you might think that central planning would work better than a multi-agent approach: after all, you could plan for an entire fleet and determine the sequence of jobs, time constraints, and practical matters such as lunch breaks, in advance. Nonetheless, the fact remains that approximately one third of trucks on the road are empty. I think we can do better than that using multi-agent systems, in which shippers put their cargoes up for auction, and transport operators bid for them. You could assign a separate agent to each truck, and distribute the tasks within a transport operator by auction. But the most important point is to learn to cope with uncertainty. In this respect, too, agents need foresight. What will it really cost me to make this trip, if it means I will miss another opportunity? How can I, as a shipper, avoid an excessive price? I investigated various price mechanisms to answer these questions. For instance, a shipper could set a reserve price: if the best bid at auction is higher than this price, it will not be accepted. Transport operators, in turn, will factor the expected future impact of an order into their bids. They can also build in an escape mechanism to enable them to withdraw from a job for which they have bid, on payment of a penalty. Suppose the transport operator, with a slight detour, could pick up a more favorable load, the advantage gained might outweigh the decommitment penalty. What you are trying to avoid with these strategies is making decisions that

with hindsight will be regretted, whether by the shipper or the transport operator, or from the point of view of total logistics costs. If you succeed, you will be making the best use of the opportunities."

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"The transport market in the United States is different from that in Europe, where there are many more independent operators with only one truck, driven by its owner. Consequently, electronic auctions for exchanging transport orders tend to be more commonplace. However, the current auctions take place without the price mechanisms I am proposing. An example of a European electronic marketplace is Teleroute, where more than 150,000 orders a day are traded. This may seem a lot, but there is much still to be gained. Furthermore, the agents in this case are ordinary people surfing the Internet. We can benefit enormously from agents with foresight that are able to cope with uncertainty. This is obviously true in financial terms, but the environment will gain if substantially fewer trucks run empty on the roads."

Martijn studied within Transumo (TRANSition SUsustainable MObility), a Dutch platform of companies, public authorities and knowledge institutes that jointly develop knowledge in the sustainable mobility field.