Chapter 34
Agent-Based Modeling for Carpooling

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ABSTRACT

Modeling activities and travel for individuals in order to estimate traffic demand leads to large scale simulations. Most current models simulate individuals acting in a mutually independent way except for the use of the shared transportation infrastructure. As soon as cooperation between autonomous individuals is accounted for, the individuals are linked to each other in a network structure and interact with their neighbours in the network while trying to achieve their own goals. In concrete traffic-related problems, those networks can grow very large. Optimization over such networks typically leads to combinatorially explosive problems. In this chapter, the case of providing optimal advice to combine carpooling candidates is considered. First, the advisor software structure is explained; then, the characteristics for the carpooling candidates network derived for Flanders (Belgium) are calculated in order to estimate the problem size.

INTRODUCTION

Modeling activities and travel for individuals in order to estimate traffic demand, leads to large scale simulations. Most current models simulate individuals acting in a mutually independent way except for the use of the shared transportation infrastructure (road and transit capacity use). In many cases those tools scale (i) linearly with respect to daily agenda generation for mutually independent agents and (ii) quadratically with the number of travel analysis zones (TAZ) due to the use of origin-destination (OD) pair based flow and impedance matrices.

As soon as cooperation between individuals is accounted for, the need for agent-based simulation arises because (i) on one hand individuals have their own goals and plans and (ii) on the other hand they need to communicate, coordinate and negotiate to achieve their goals. This results in rapidly increasing problem complexity (combinatorial explosion). Agent-based simulations are known not to scale well. However, some problems raise questions that can be answered using this technique only.

This chapter focuses on the specific transportation related problem of *carpooling for commuters*. This case has been chosen because the study of scalability questions requires a well defined problem (and application context) in order to apply the results of mathematical and computer science research. The concept of *shared trip execution* is diverse. First the context is sketched both by analysing the essential phenomena relevant to cooperation and by showing a selection of existing advisory services available to candidate carpoolers today. Then, the principle of operation for a *commuter trip matching advisory service* is described. In order to analyse the behaviour of such advisor, it can be exercised by virtual community implemented by an agent-based simulator. The objectives are (i) analysing the advisor behaviour in order to tune the built-in machine learning mechanism and (ii) evaluating the transient phenomenon between initial deployment and the state in which the required critical mass of users has been attained. The last section presents initial results calculated from schedules generated by the FEATHERS activity-based model for the six million population in Flanders.

Carpooling is a form of cooperation while executing a daily agenda hence requiring coordination between people. In actual practice, carpooling and similar concepts can be supported by intelligent advisory systems for trip matching. Evaluating the operational fitness of such systems in the testing phase requires an active community of users. This chapter focuses on the use of an agent-based model to exercise the advisory system under test.

Carpooling as a Specific Instance of Cooperation

Carpooling has been the subject of investigation since it is a travel mode that can help to mitigate adverse effects caused by high transportation demand.

Carpooling implies cooperation. Most models for transportation demand either operate at aggregate levels (like the well known four step models (FSM)) or consider microsimulated actors to be mutually independent, except for the space they occupy on the road network while traveling. Carpooling is a phenomenon where cooperation is essential. Modeling actor interactions generates new challenges for research. Many cooperation problems require some form of combinatorial optimization. In the DataSIM project, the problem of carpooling was introduced in order to study the scalability of microsimulators involving interacting individuals.

This chapter concentrates on carpooling for commuting which means long term cooperation on periodic trips in the european context. The relationship between HOV lane advantages and carpooling is not considered because it is not relevant for the situation in the study area of DataSIM (Flanders, Belgium).

Advisory Services

It is assumed that people looking for carpooling partners first explore their own social network consisting of family members, neighbors, colleagues and acquintances. When no partner can be found in this way, individuals start consulting public services like websites for global exploration.

Nowadays a diverse set of advisory websites for carpooling is available. Those websites can be distinguished by the *services supplied*, by the integrated *automatic matching mechanism* used (if any) and the set of parameters used in the matching process (characteristics and preferences for the individual, trip times, routes driven), by the *business model* for payment handling, by the *types of co-traveling* supported (carpooling, van-sharing, ridesharing, …) covered and by the *target user community* addressed (individuals or companies). A categorization is given below (see table in appendix).

Several of those websites contain *matching services* which means that they can suggest specific trips to be combined in a carpool. From a business

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