Available online at www.sciencedirect.com

ScienceDirect

Procedia Computer Science 52 (2015) 412 – 419

Procedia Computer Science

The 6th International Conference on Ambient Systems, Networks and Technologies (ANT 2015)

Agent-based Simulation Model for Long-term Carpooling: Effect of Activity Planning Constraints

Iftikhar Hussain[a,]*, Luk Knapen[a], Stephane Galland[b], Ansar-Ul-Haque Yasar[a], Tom Bellemans[a], Davy Janssens[a] and Geert Wets[a]

[a] *Transportation Research Institute (IMOB), Hasselt University, Wetenschapspark 5 bus 6, 3590 Diepenbeek, Belgium*
[b] *Multiagent Group, IRTES-SET, Université de Technologie de Belfort-Montbéliard, 90010 Belfort cedex, France*

Abstract

In order to commute by carpooling, individuals need to communicate, negotiate and coordinate, and in most cases adapt their daily schedule to enable cooperation. Through negotiation, agents (individuals) can reach complex agreements in an iterative way, which meets the criteria for the successful negotiation. The procedure of negotiation and trip execution in the long-term carpooling consists of a number of steps namely; (i) decision to carpool, (ii) exploration and communication, (iii) negotiation, (iv) coordination and schedule adaptation, (v) long term trip execution (carpooling), (vi) negotiation during carpooling and (vii) carpool termination and exploration for new carpool. This paper presents a conceptual design of an agent-based model (ABM) of a set of candidate carpoolers. A proof of concept implementation is presented. The proposed model is used for simulating the interactions between autonomous agents. The model enables communication to trigger the negotiation process; it measures the effect of pick-drop and shopping activities on the carpooling trips. Carpooling for commuting is simulated: we consider a set of two intermediate trips (home-to-work and work-to-home) for the long-term carpooling. Schedule adaptation during negotiation depends on personal preferences. Trip timing and duration are crucial factors. We carried out a validation study of our results with real data (partial) collected in Flanders, Belgium. Simulation results show the effect of constraining activities on the carpooling trips. The future research will mainly focus on enhancing the mechanisms for communication and negotiation between agents.

Peer-review under responsibility of the Conference Program Chairs

Keywords: Negotiation; carpooling; commuting; Agent technology; Organizational model; Janus platform.

* Iftikhar Hussain. Tel.: +32-11-269169; fax: +32-11- 26 91 99.
E-mail address: iftikhar.hussain@uhasselt.be

Peer-review under responsibility of the Conference Program Chairs
doi:10.1016/j.procs.2015.05.006

1. Introduction

Carpooling is considered to be an effective alternative transportation mode that is eco-friendly and sustainable as it enables commuters to share travel expenses, save on fuel and parking costs, improve mobility options for non-drivers and it also reduces emission and traffic congestion. Change in some socio-economic characteristics (SEC) such as the increase in fuel price, in parking costs, or in the implementation of a new traffic policy, may prove to be an incentive to carpool. Strict timing constraints in the schedule of the day however, have the opposite effect. In order to commute by carpooling, individuals need to communicate, negotiate and coordinate, and in most cases adapt their daily schedule to enable cooperation[1,8].

While traditional modeling tools cannot handle the complexity of negotiation for carpooling, agent-based models (ABMs) are able to do so through modeling the interaction of autonomous agents[7]. The ABM aimed at simulating the actions and interactions of autonomous agents, are not limited to computer science but are also used in other domains including biology, ecology and social sciences. Currently many research areas including transportation behavior need to analyze and model complex interactions between different autonomous entities[7].

The aim of this research is to generalize the concept of communication, negotiation and coordination in a *multiple trip negotiation model* by taking the possibility of flexible activity scheduling into account. It also focuses on the setup of the simulation framework and the network of the carpooling candidates. The agents can communicate with the individuals sharing the same home and work locations within a small group by taking SEC (vehicle and driving-license ownership) into account. Furthermore they negotiate about trips (home-to-work and work-to-home) timings in order to adapt their daily schedule. The ability to carpool for commuting depends on schedule flexibility. A daily schedule for each individual is considered. They consist of different activities, one of them must be (flexible) work activity.

The model is based on an agent-based and organizational meta-model[12], in which the role and organization concepts are first class entities. In the proposed conceptual model agents are the individuals, who negotiate to reach an agreement to carpool. The carpooling related actions performed by agents are divided into two main categories: exploration (communication and negotiation) and trip execution (coordination, negotiation during carpooling and carpooling). During the exploration the agent looks for other individuals to cooperate on commuting trips during a period of multiple months. Agents explore their social network by sending requests for carpooling. While negotiating, agents can reach complex agreements depending on the *matching mechanism* (discussed in section 3.3), used to match with preferences, which are expressed by all negotiating partners. For the trip execution, carpoolers need to coordinate with each other for the long-term carpooling. Carpoolers may (re)negotiate timing and/or (re)schedule their agenda when someone joins or leaves the carpool. The Janus[11], agent based platform is used; it provides an efficient implementation of organizational-based and agent-based concepts.

This paper is organized as follows; first the related work on carpooling and ABM are briefly described in section 2. Section 3 covers the long-term carpooling behavioral model. Section 4 explains the experimental setup and some results. Finally, conclusions and future work are presented in section 5.

2. Related Work

According to literature, agent-based models are also used in non-computing related scientific domains and can provide valuable information on society and the outcomes of social actions or phenomena. A detailed literature review [9,10,] focuses on technical development of the carpooling support systems, and empirical, interrelationships between willingness to carpool and socio-economic attributes of carpooling, is presented.

Galland et *al*.[2] presented a conceptual design of an ABM for the carpooling application, that is used for simulating the interactions of autonomous agents and to analyze the effects of change in factors of infrastructure, behavior and cost. This model used agents' profiles and social networks to initialize communication and then employ a routing algorithm, and a utility function to trigger the negotiation process between agents. Authors showed computation time of carpoolers by taking different number of agents as input.

Hussain et *al*.[6] proposed a single trip negotiation model for carpooling using a simple negotiation mechanism. The first implementation used home and work locations as well as preferred trip start times and carpool periods determined by uniformly sampling given sets. The authors extended the single-trip negotiation mechanism into a