The BDI Driver in a Service City

Extended Abstract

Marco Lützenberger Nils Masuch Benjamin Hirsch
Sebastian Ahrndt Axel Heßler Sahin Albayrak

DAI-Labor, Technische Universität Berlin
Ernst-Reuter-Platz 7
10587 Berlin, Germany
firstname.lastname@dai-labor.de

ABSTRACT

Most traffic simulation frameworks move vehicles from some location A to some location B as the result of different equations of motion or fluid dynamics. As it is, reality is much more complex because what actually happens on the road is not only determined by physics of motion, but also by the perception and attitudes of the drivers. In this work, we introduce an approach which considers a driver's state of mind within large scale traffic simulations. For this purpose we describe a BDI based conceptualisation of a driver and extend common simulation topologies with service oriented concepts.

Categories and Subject Descriptors

I.2 [**Computing Methodologies**]: Distributed Artificial Intelligence—*Intelligent agents*; I.6 [**Simulation And Modeling**]: Model Development

General Terms

Human Factors, Experimentation, Measurement

Keywords

BDI, Simulation techniques, tools and environments

1. INTRODUCTION

Despite the wide range of available traffic simulation frameworks, most products share the fact that the vehicle simulation is done in a pure computational fashion. Usually, the simulated vehicles are moved from a location A to a location B as a result of equations of motion or fluid dynamics. As it is, reality is much more complex, because what actually happens on the road is not only determined by physics of motion, but also by the perception and attitudes of the drivers. A driver with a high affinity for public transport for instance might change his means of transportation when confronted with a traffic jam near a metro station and available parking. This aspect does not affect the driving process per se, but influences the traffic situation a fortiori. Several approaches [1, 2, 3, 5], integrate stimuli-reaction principles and mimic individual driving styles by implementing cognitive abilities for the simulated vehicles. Yet, a more comprehensive, “strategic” consideration is mostly missing. In this paper we outline an according approach. We start by explaining the model we have specified for the driver and emphasise additional requirements for the topology model which are necessary to make this approach work.

2. THE BDI DRIVER IN A SERVICE CITY

For our purpose, we have to address two topics. First, we have to define a model for the environment which is able to influence the behaviour of a driver by certain stimuli. Next, we have to define the behavioural model for the driver, which is able to comprehend the stimuli of the environment and is able to generate the driver's action.

The main difference between our approach and related work is that a driver is able to perceive and interact with his topology by making use of certain *Infrastructural Features* which may support the driver in achieving his goals, or influence his strategy in doing so. We define the term as follows: *An Infrastructural Feature can be everything which is able to fulfil a desire (or parts of it) of a person at a certain location of an infrastructure.* As an example, consider public transport. It provides a service at many places of an infrastructure and supports a person's desire to reach a certain location. Another example is a car park. Located at some location they provide service for any driver who wants to park his vehicle. According to our definition, *Infrastructural Features* are not necessarily related to traffic, but can also be interpreted as: Shop, restaurant, takeaway, telephone booth and many more. Based on our definition, it is nearly impossible to provide a complete model for any larger city; this is not our intention. Our objective is to provide a uniform way for the specification of these features in order allow for easy, custom definitions. We choose the **Service Metaphor** for this purpose and allow for a unified specification in terms of preconditions, effects, a scope, a location (or more than one, in case of a cross-linked service, such as a metro system) and a duration function.

For the implementation of the **Driver Model**, we apply an agent oriented view [6] and follow a popular model for the conceptualisation of human behaviour: *The BDI model* [4]. This approach provides us with a specification for our im-

Cite as: The BDI Driver in a Service City, Marco Lützenberger, Nils Masuch, Benjamin Hirsch, Sebastian Ahrndt, Axel Heßler and Sahin Albayrak, *Proc. of 10th Int. Conf. on Autonomous Agents and Multiagent Systems (AAMAS 2011)*, Tumer, Yolum, Sonenberg and Stone (eds.), May, 2–6, 2011, Taipei, Taiwan, pp. XXX-XXX.

plementation and a validation of the agent's behaviour. We can implement critical processes in terms of several distinct modules, each one realising a particular phase of the agent's overall behaviour. The operation principle and behaviour phases of our BDI agent are illustrated in Figure 1.

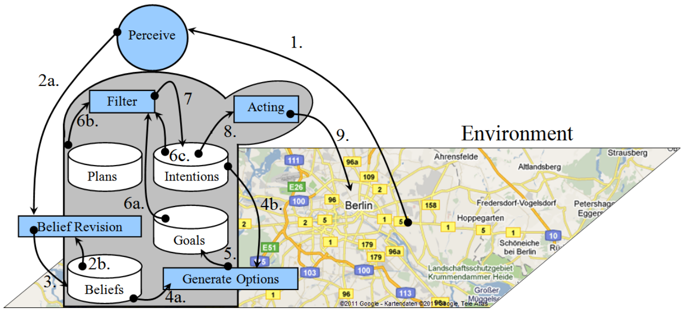

Figure 1: The architecture and actuation principle of our driver agents.

Actuation comprises four phases. The simulation engine uses the location and the scope to determine if a driver perceives an infrastructural service (1). If he does, the agent starts with the *Belief Revision* phase, in which he extends (3) his belief base by newly perceived services and removes out-dated beliefs (2b) which are no longer required. Using his updated belief base (4a) and his current intentions (4b), the agent proceeds to the *Generate Options* phase, in which the preconditions of each service in the belief base are evaluated. Depending on the specification of the service's preconditions, generic reasoners or self-coded methods can be used here. In case of a positive evaluation of the precondition, the desire to make use of the service will be stored in the form of a goal within the goal base of the agent (5). In combination with the agent's basic plans (walk and drive) and his current intentions, the new set of goals constitutes the input (6a, 6b, 6c) for the *Filter* phase. We distinguish between two types of goals. While the main goal expresses the agent's main objective to reach a certain location, only (sub-)goals can emerge dynamically indicating an agent's desire to make use of a perceived service. By accessing their effects, the agent computes any possible permutation service use and measures —according to his preferences— which strategy is able to support him best in achieving his main goal. Finally, the favourite strategy is selected and inserted into the agent's intention repository (7), from which his actuation is derived (8) and his environment influenced (9) once more.

3. LET THEM ROLL

In the following example, we develop service definitions for a metro station and a car park and evaluate the influences of varying acceptances towards the usage of a public transport service on the overall traffic situation. We place three instances of the metro service into the simulation topology and while the different instances are be located at different positions, the effect of each service is to move the executing driver to the same exit. We further define several parking services, each one with an initial capacity of 2000 parking lots. We manipulate the filter phase of agents to mimic adjustable acceptances towards the metro service and perform several simulations in which respectively 10.000 vehicles drive from an appointed source region to an appointed target region. We illustrate selected results in Figure 2.

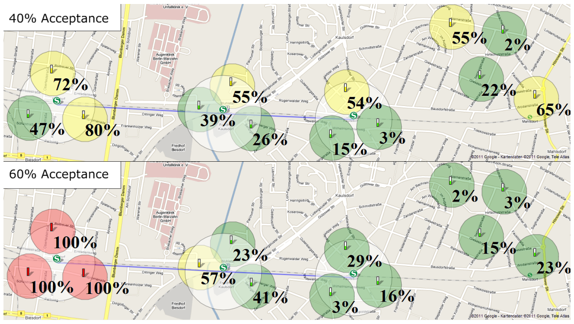

Figure 2: Results of the simulations, showing the car park's utilisation in percentage values.

Each illustration shows the capacity utilisation of respectively one car park by means of coloured circles. Red circles represent utilisations beyond 90%, yellow circles represent utilisations beyond 50% and green circles represent utilisations below 50%. One can clearly see that different user profiles tend to influence the overall traffic situation differently. Where a low service acceptance results in a high utilisation of the parking services within the target area, an increasing acceptance causes a migration of the utilisation peak, until it is not possible to make use of the first metro station, because its parking capabilities are exhausted. According to these results, we can observe that different user profiles influence traffic situations differently and conclude, that the consideration of these parameters is able to increase the quality of simulation results.

4. REFERENCES

[1] U. Beuck, K. Nagel, M. Rieser, D. Strippgen, and M. Balmer. Preliminary results of a multiagent traffic simulation for berlin. *Advances in Complex Systems*, 10(su):289–307, 2007.

[2] P. A. M. Ehlert and L. J. M. Rothkrantz. A reactive driving agent for microscopic traffic simulations. In *Proceedings of the 15th European Simulation Multiconference, Prague, Czech Republic*, pages 943–949, 2001.

[3] P. Paruchuri, A. R. Pullalarevu, and K. Karlapalem. Multi agent simulation of unorganized traffic. In *Proceedings of the 1st International Joint Conference on Autonomous Agents and Multiagent Systems, Bologna, Italy*, pages 176–183, 2002.

[4] A. S. Rao and M. P. Georgeff. BDI agents: From theory to practice. In *Proceedings of the 1st International Conference on Multiagent Systems, San Francisco, CA, USA*, April 1995.

[5] M. Rigolli and M. Brady. Towards a behavioural traffic monitoring system. In *Proceedings of the 4th International Joint Conference on Autonomous Agents and Multiagent Systems, Utrecht, Netherlands*, pages 449–454, 2005.

[6] M. Wooldridge and N. R. Jennings. Intelligent agents: Theory and practice. *Knowledge Engineering Review*, 10(2):115–152, June 1995.