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Need-Based Activity Planning in an Agent-Based Environment

David Charypar
Andreas Horni
Kay W. Axhausen

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1 Introduction

One important observation when we want to understand travel as a phenomenon is that it emerges from the desire of people to execute different activities at different places in the world. For travel behavior analysis therefore, understanding the activity scheduling process is crucial.

We believe that the relevant effects can best be captured by using a microscopic approach, by looking at the individual. Consequently, the presented work is in the context of an agent-based integrated transport simulation framework: A synthetic population of agents lives in a virtual world in which they can move around using a transport infrastructure. Facilities suitable for execution of activities have different locations and every activity needs to be associated to such an facility. Each agent now creates a detailed activity plan consisting of activity types and order, locations, times, travel modes, routes etc. that describes its intended actions. During the execution of their plans agents interact in the virtual environment thereby producing emerging phenomena like congestion, delays and overcrowding potentially leading to a reduction of the utility of the executed plan.

An important and difficult question is how generate such a complete activity plan. On possible way is to start from a list of available activities, define a utility function of activity execution and to try to maximize the gained utility using genetic algorithms (Charypar and Nagel [2005]). While this approach has proved to work sufficiently well for the simulation of average work days (Balmer et al., forthcoming) it also has several drawbacks:

- The list of activities has to be pre-specified.
- The plan duration has to be fixed, e.g. 24 hours, even though longer plans are possible.
- The whole plan is optimized at once, making this approach computationally relatively inefficient.
- It is difficult to have multiple instances of the same activity type in the same activity plan due to unrealistic repetitive activities.

2 Our Contribution

In this paper, we present how the discussed problems can be solved by explicitly modeling the the inner state of the agents. This state represents explicitly the basic needs of every person. In our case we model need for regeneration, exercise, food, work / education and leisure. It is the satisfaction of such needs that produces utility. If there is no need for an activity, the execution thereof will not produce any resulting utility. This has the desired effect that the
repeated execution of the same activity at the same place does no longer represent a gain in utility which was the case using earlier stateless utility functions. On the other hand, if an urgent need stays unsatisfied the corresponding utility will be very low. An activity plan can now be considered good if it keeps all needs at a reasonable level of satisfaction.

Our model is similar to concepts found in (Arentze and Timmermans, 2006, in press), where a first coherent quantitative modeling framework for generating activities based on need of household members is presented. However, their work focuses on the generation of activity agendas using a greedy rule-based algorithm, leaving the actual scheduling of activities to a later process.

In our work, this scheduling process represents an integral part of the model, relaxing the hard distinction usually made between activity agenda generation and activity scheduling. Another key feature of the presented model is that all activities are described by a signature, two functions that describe how an agent’s state is changed through activity execution and what utility is produced.

The build-up of need levels plays a central role in activity pattern generation as this is a relatively predictable process: By extrapolation one can easily find lower and upper temporal bounds for scheduling a certain activity. These bounds reduce the size of the search space in time and space an thereby contribute to keep the computational effort bounded. We furthermore control the computational complexity of the resulting optimization problem by subtracting the expected replanning costs from the over all utility of the activity plan. This produces the somewhat behaviorally justified effect that existing plans are only changed if the estimated gain in utility is substantial.

The paper describes how an existing framework is extended by the inner need of the agents and how the activity signatures for the five basic needs were designed to produce realistic activity patterns. We describe the optimizer (from the class of evolutionary algorithms) that we developed and first results with synthetic and reality-based scenarios. As one of the key aims of the model is efficiency, performance measurements form an important part of the paper.

References

