Agent-based simulation of mobility in real-world transportation networks: effects of acquiring information and replanning en-route

(Extended Abstract)

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ABSTRACT

Macroscopic and equilibrium-based models for traffic assignment and simulation disregard many details of traffic movement. For some applications, one needs to understand and analyze microscopic properties. This paper discusses an agent-based simulation of route choice under different conditions of demand generation, number, and types of travelers. The effects of en-route decision-making and vehicle-to-vehicle communication were tested in a real-world scenario. The analysis has considered different classes of travelers, which is only possible if a microscopic, agent-based simulation is used. The main conclusion is that for travelers whose trips are long, there is a benefit of using communication and replan en-route, depending on the demand volume.

Categories and Subject Descriptors

I.2.11 [**Artificial Intelligence**]: Distributed Artificial Intelligence—*Multiagent Systems*

General Terms

Experimentation, Human Factors

Keywords

Traffic Simulation, Agent-based Simulation,V2V

1. INTRODUCTION

Macroscopic simulation methods for assignment of traffic demand are generally based on equilibrium computation and assume steady state conditions on the links. Thus it is less useful when one intends to do microscopic investigations related to short time frames and travelers' individual features such as local perception of the traffic state, ability to communicate (e.g. by means of vehicle to vehicle communication or simply V2V), or replan en-route. Also, the computation of the exact equilibrium is not only a non-trivial problem, but also it is probably a useless effort given that this equilibrium will not last long due to the dynamic nature of the environment. Therefore, we follow a different line, namely dynamic traffic network disequilibrium. Here, one basic assumption of equilibrium-based approaches is relaxed: users are no longer assumed to be fully and accurately informed. Rather, disequilibrium research focuses on the adaptation process by which users' experiences in one period of time affect their decisions in subsequent periods.

In order to tackle this detailed representation of the demand and, especially, of the user's adaptation, in the present paper agent-based simulation is used. Thus, instead of using volume-delay functions (functions that express the average or steady-state travel time on a link in terms of volume in this link) to estimate costs, the actual travel time of each driver in each link results from the actual driving.

Intuitively one assumes that broadcasting information to the user of a transportation network is only beneficial if it is *not* the case that everyone receives the same information, at least not in networks that operate close to the saturation level in key portions of it. Therefore, the aim of this work is to investigate whether drivers could do better by using only local perception, i.e., the (partial) information is collected by the driver itself. Later we extend this concept to include information that is also gathered by means of V2V.

Several publications suggest the application of intelligent agent architectures to different travel-related choice processes such as route and mode choice. Agent based approaches seem to be particularly relevant when networks are dynamic or when dynamic information is available. As mentioned, a large number of works about the effect of information on route choice uses abstract scenarios based on static assignment and/or VDF. These abstract scenarios are mostly inspired by congestion or minority games. Examples are for instance Bazzan *et al.* [4] and Chmura and Pitz [3]. Similar goals to our work appeared in [1] but it was mentioned that when en-route replanning is to be included, the situation becomes considerably more complicated. This explains why en-route replanning is seldom considered in other approaches. Thus, the contributions of this paper are the use of agent-based paradigms to simulate the effect of en-route replanning and different levels of information.

2. METHODS

In order to implement this kind of simulation we use the microscopic traffic simulator ITSUMO [2] to represent the actual movement of the vehicles. Next we briefly describe the main steps.

Demand generation. Demands are represented by an

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O-D (origin-destination) matrix. The O-D used here resembles roughly the main origins and destinations of the city of P. Alegre (Brazil). Besides these real-world data, in this paper we also use a uniformly distributed demand. See [2] for a discussion of these two types, in a smaller scenario.

Agent-based routing. ITSUMO allows the use of various algorithms (Dijkstra, A*, ARA*, anytime and dynamic shortest path algorithms for route computation). In [2] all algorithms were evaluated with the conclusion that normally A* is a good compromise between efficiency and cost. Therefore here A* is used here. In the traditional, macroscopic approach, routes are computed by a central entity and are assigned to users. Then, an iterative process occurs in which only some users' routes are adjusted in order to converge to the equilibrium. This makes sense in a centralized, non-agent based approach in which there is no autonomy by the agent itself. In contrast, in the agent-based case, given an O-D pair, the agent's knowledge about links traffic volume, and an algorithm such as A*, the agent itself computes its initial best route and departures. After, as the journey proceeds and more information is incorporated, this is used in the next journey or even during the same journey to perform some en-route re-planning.

Drivers and en-route re-planning. One of the important features is the driver's ability to re-plan during the trip when facing congestion (henceforth *en-route* planning).

Types of Agents. Combining the capabilities and knowledge of the agents, we came out with four kinds of simulation: FNR stands for full knowledge and no replanning; FR means that drivers do en-route replanning; P means local perception (thus partial knowledge); PC is local perception plus V2V. If the agent has access to full information, it knows the current demand at all links. If it does not, it may perceive it locally, thus having only partial information. In this case, it only knows volumes of those links it has traveled recently. Further, we test drivers equipped with V2V devices, which enable agents to have further information about traffic volume. Regarding en-route replanning, this is done periodically and is based on the information the driver has about the other links of the network.

3. SCENARIO AND RESULTS

Due to lack of space, we focus on the main conclusions that were drawn after running the simulations for the different demand sizes and all four classes of agents types. In all cases we have analyzed the number of trips performed (within the simulation horizon) and average travel time over all drivers (given in simulation steps). To take advantage of agent-based simulation, we have generated agents' performances by individual classes.

Analysis over All Classes of Trip Duration. When all drivers are considered, drivers with full knowledge perform better than those with partial knowledge. However, the important conclusions related to differences noticed when different classes of trip duration are considered, as next.

Analysis Within Classes of Trip Duration. Intuitively, one expects that the effects of en-route replanning and of the V2V be more significant for drivers whose trips take longer. This is what was observed in most cases. However there are differences in performance if the demand is uniform or O-D-based. In the former, for drivers whose trip take long, PR and P outperform FR, which outperforms FNR, i.e., partial information is valuable. In the O-D demand, full knowledge pays off only if the driver is able to replan en-route (the best performance is FR). There are two reasons for this. First, local perception seems not to be valuable (and hence neither V2V as this only spreads non-accurate perceptions). This is probably due to the fact that the network being big, the trips take long so that the acquired knowledge is not accurate after some time. The second is that if the driver is not able to replan en-route, then there is a chance that many drivers plan their routes over the same portion of the network and get stuck to them.

These results indicate that in more realistic network, as it is the case of O-D demands, there is a positive utility in performing en-route replanning when trips take a long time. This is not the case regarding short trips, probably because there is a cost of changing routes.

4. CONCLUSION AND FUTURE WORK

A summary of the investigations conducted by us is that there are differences among distinct classes of drivers, regarding trip duration, type of knowledge and ability. A macroscopic approach would only conclude that, for the overall population of agents, having full knowledge is advantageous. However, using a microscopic analysis that considers different types of drivers, it is possible to see that having full knowledge seems to be advantageous only if replanning is possible. We remark that the method proposed is general. One needs only to plugin its own scenario and O-D description in ITSUMO in order to generate these kind of data and analysis. Future work regards the decoupling of en-route replan and communication in order to better understand the effects of each.

Acknowledgments

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