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Within day rescheduling microsimulation combined with macrosimulated traffic

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ABSTRACT

The concept of rescheduling is essential to activity-based modeling in order to calculate effects of both unexpected incidents and adaptation of individuals to traffic demand management measures. When collaboration between individuals is involved or timetable based public transportation modes are chosen, rescheduling becomes complex. This paper describes a new framework to investigate algorithms for rescheduling at a large scale. The framework allows to explicitly model the information flow between traffic information services and travelers. It combines macroscopic traffic assignment with microscopic simulation of agents adapting their schedules. Perception filtering is introduced to allow for traveler specific interpretation of perceived macroscopic data and for information going unnoticed; perception filters feed person specific short term predictions about the environment required for schedule adaptation. Individuals are assumed to maximize schedule utility. Initial agendas are created by the FEATHERS activity-based schedule generator for mutually independent individuals using an undisturbed loaded transportation network. The new framework allows both actor behavior and external phenomena to influence the transportation network state; individuals interpret the state changes via perception filtering and start adapting their schedules, again affecting the network via updated traffic demand. The first rescheduling mechanism that has been investigated uses marginal utility that monotonically decreases with activity duration and a monotonically converging relaxation algorithm to efficiently determine the new activity timing. The current framework implementation is aimed to support re-timing, re-location and activity re-sequencing; re-routing at the level of the individual however, requires microscopic travel simulation.

1. Introduction

Nowadays, activity-based models are used to generate daily schedules for members of synthetic populations in order to estimate time dependent travel demand. Microsimulation allows to take into account specific traits for each individual so that sensitivity to travel demand management (TDM) measures can be modeled at the level of the individual actors. The overall effect of those measures then emerges from the simulation. Many models assume that daily planning decisions are taken one day ahead and predict schedules that are assumed to be immutable (i.e. executed exactly according to the plan). In actual practice, most people adjust their daily schedule during execution, either because of unexpected event occurrence or because the individual discovers new opportunities or acquires more complete information. Accounting for this

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phenomenon, requires schedule (daily agenda) *execution* simulation. While executing the predicted schedule, individuals make use of the shared transportation network facilities. Each individual has incomplete or biased knowledge of the environment; this phenomenon is modeled via *perception filters*. The environment can change due to exogenous phenomena that affect the shared resources (e.g. a traffic incident or adverse weather conditions can decrease the network capacity in some region). As a consequence, some individuals adapt their planning which affects the load on the network which in turn affects the available capacity as a function of time and space. In the WIDRS (Within Day Re-Scheduling) model, information about the environment is fed back to the individual. Actor behavior is determined by the perceived state of the network and by expectations about its short term evolution. The schedule execution simulator does not strive to an equilibrium state because that would require information about the future; the system never is assumed to be in a steady state.

1.1. Aim of the paper

Both the basic concepts and model details for the WIDRS project are described. The first part of the text discusses related research and shows the principle of operation; it gives an overview of building blocks involved and highlights their interactions. The second part starting at Section 4 explains details of several essential components. Section 5 discusses the results for an experiment involving the evaluation of the effect of a large scale road capacity reduction. Sections 7 and 6 present conclusions drawn from the experiment and plans for the future.

1.2. Project objectives

The WIDRS framework is a software tool to evaluate schedule adaptation by individuals as a response to changed conditions in the environment. This project is part of our research efforts concerning dynamic activity-based simulation. Mutual dependency of individuals only is caused by sharing limited capacity resources. Direct interactions between individuals are not considered. The WIDRS project is aimed at large scale simulations used to investigate traffic demand management (TDM) measures. The experiment described here aims at quantifying the effect of an unexpected incident on both the schedules and on the time-dependent road network conditions. The incident (traffic accident, non-predicted meteo condition) is modeled by local capacity reduction on the road network.

2. Related work – context

2.1. Research on schedule adaptation

In a first category of research efforts, mechanisms underlying the schedule construction and schedule adaptation processes are investigated. The *Aurora* model developed in Joh (2004) provides for schedule generation and dynamic activity-travel rescheduling decisions. *Aurora* is based on S-shaped utility functions. The maximal utility value attainable for a given activity, is given by the product of functions modeling the attenuation by start time, location, position in agenda and time gap since last execution of the activity. Bounded rationality individuals are assumed. Arentze et al. (2005) present a comprehensive description of *Aurora*. People are simulated as individual agents. A comprehensive model has been specified describing the insertion, re-positioning, deletion and substitution of activities as well as changing locations, trip chaining options and transport modes. Models of this level of detail are required to integrate cooperation concepts in a simulator (e.g. joint activity execution or carpooling). The paper describes the use of *Aurora* in an experimental setup to study schedules consisting of work activities and green recreation activities in several scenarios.

Recker (1994) and Gan and Recker (2008) present a mixed integer programming formulation of the HARP problem (Household Activity Rescheduling Problem). Both papers report on an extensively elaborated rescheduling model that has been applied to a small amount of individuals suffering from a pre-specified loss of time. The idea is that while planning, people solve a MILP (mixed integer linear program). The examples given show that realistic schedules are produced. However, the number of constraints required in the model is large. The level of detail does not allow for large scale deployment.

Jang and Chiu (2010) describe a model that uses a quadratic utility function and integrates the scheduler with a dynamic traffic assignment tool DynusT. A similar approach has been taken by Bekhor et al. (2011) who integrated an activity-based model for Tel-Aviv with the MATSim toolkit allowing for re-timing and re-routing.

Jenelius et al. (2011) analytically derive the optimal timing in a schedule composed of three activities and two trips. The authors analyze a model using marginal utility functions that are linear combinations of time-of-day based and duration based components.

Pendyala et al. (2012a) present the integration of the open source travel demand model *OpenAMOS* with the traffic microsimulator *MALTA* (Multi Resolution Assignment and Loading of Traffic Activities) in SimTRAVEL. That is used to determine the effect of unexpected network disruption. The impact of the disruption and the network congestion dissipation dynamics are calculated for several information provision scenarios. For each minute of the day, the demand model simulates activity-travel engagement decisions for all individuals. The results are fed into the traffic assignment model that routes the trips from origin to destination and simulates car movements. Network skims by time of day are used to feed back expected travel times to the activity-based model. Unfortunately, the paper does not explain the schedule adaptation model.