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Transportation System Modeling in the Information Era

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INTRODUCTION

Enabled by advances in technology, Real-time Information Systems (RITS) are increasingly being deployed as a solution to address the congestion issues we face today. RTIS solutions aim to provide roadway users with up to date information on travel times along roadway corridors allowing users to make informed decisions about routes, destinations, modes, and/or activity scheduling and sequencing. RTIS promises the ability to provide up-to-the-minute network-wide traffic conditions to people through a variety of technological solutions including smart phones, global positioning systems, and in-vehicle technologies. The potential of RTIS for improving the efficiency of different aspects of the activity and travel choices is undisputed. However, individuals may access and use the information to different extents and in different ways, with due consideration to their unique contextual situations characterized by time-space constraints, household obligations and interactions, modal availability and accessibility, and built environment attributes. The net impact of a RTIS strategy on activity-travel patterns of individuals, and on the transportation network as a whole, is complicated to assess. Therefore, there is a need for a comprehensive model system that can be utilized to systematically assess the direct and cascading impacts of real-time services such as RTIS. The focus of this research effort was twofold, namely, 1) develop a conceptual modeling framework for the activity-travel generation problem to accurately represent the behavioral dynamics that result from information provision and usage and 2) implement the conceptual framework using existing microsimulation models of travel demand and dynamic traffic assignment to build an integrated model prototype. In the next section an overview of the conceptual modeling framework is presented. In the following section, the prototype of the integrated model system is described. In the last section, ongoing and future research on the topic are described.

DYNAMIC TIME-CONTINUOUS INTEGRATED MODEL FRAMEWORK

In modeling transportation systems, two types of models are applied, namely, an activity-based travel demand model and dynamic traffic assignment models. In the activity-based travel demand model, different dimensions of household and individual activity participation and time use including (how, when, what, and with whom) are modeled. Additionally, various dimensions of the trips (resulting from participating in activities separated in space) are also modeled in the activity-based travel demand model. On the other hand, in the dynamic traffic assignment model, choices related to the execution of the trips namely path chosen, and the vehicular movements are modeled. An approach that is often proposed to integrate the two components is to apply the model systems sequentially and interface the component systems through input-output data flows and feedback loops. The sequential application works well for most planning and policy applications, but falls short of being able to simulate network dynamics and adjustments to activity-travel choices that occur in response to network dynamics (and real-time information provision about network conditions). In a dynamic approach to integration, the travel demand and traffic assignment models run in parallel along the continuous time axis constantly exchanging information. In every simulation minute, the travel demand model sends information regarding the trips that need to be simulated. The traffic assignment model then identifies the routes and models the vehicular movement through the network. Once the trip has been completed (i.e. the person or travel party has arrived at the destination), the traffic assignment model sends the information back to the travel demand model to make activity and travel choices for the subsequent time periods. It can be seen that the tight integration between the travel demand and traffic assignment model systems along the continuous time axis enables the dynamic framework to be able to capture the within day activity-travel dynamics which is otherwise not possible in the sequential integration. In this research, the dynamic approach to integration was implemented to model the impacts of different RTIS strategies.

PROTOYPE OF THE INTEGRATED MODEL FRAMEWORK

openAMOS was the implementation of choice for the activity-based travel demand model component of the integrated model. openAMOS stands for open-source Activity Mobility Simulator. The model system is composed of two main modules. First module is a household attribute generation system which generates a synthetic population, fixed activity location choices, and fixed activity episodes to mimic the individuals for the given study area. The second module is a prism constrained activity travel simulator which then generates the different activity-travel choices consistent with the principles of an activity-based model system. The resulting output is the full range of choice dimensions of different activity and travel episodes pursued by individuals in the study area. DTALite was the dynamic traffic assignment model implementation choice for this research. DTALite stands for Light-weight Dynamic Traffic Assignment Engine. DTALite produces a variety of outputs regarding network conditions at both the trip-level and link-level. On the trip side, the output includes travel duration, path, and travel distance. On the other hand at the link-level, outputs include average speed, average travel time, queue length, vehicle volume, and delay among others.

The openAMOS and DTALite implementations had to be extended to be able to realistically model the impacts of RTIS solutions. While the primary objective of the prototype was to model the impacts of RTIS, the prototype was also being developed to achieve a number of other applications in the realm of Active Transportation and Demand Management (ATDM) and Dynamic Mobility Applications (DMA) as part of other research efforts. As a result, enhancements to the prototype were broken down into four phases. The capabilities of the prototype at the end of each of the four phases are described below:

1. Level 0 Integration: Implements baseline integration of openAMOS and DTALite with no pre-trip or enroute behaviors.
2. Level 1 Integration: Implements all pre-trip decision making in activity-travel choices. All information is available to traveler prior to embarking on trip and choices are simulated based on pre-trip information. No en-route adjustments to activity-travel choices. Traveler continues to intended destination along the planned route regardless of changes in prevailing network conditions and attributes.
3. Level 2 Integration: In addition to Level 1, implements en-route decision making for route choice plus addition of lane choice simulation capability (managed lane applications).
4. Level 3 Integration: In addition Level 1, implements en-route decision making for activity and travel choices (including route choice and lane choice)

Within this research, Level 2 Integration was achieved. The integrated model prototype was also evaluated using Sioux Falls test network. The prototype is providing plausible results for the impacts of different RTIS scenarios.

ONGOING AND FUTURE WORK

Efforts are currently underway to complete the Level 3 integration. The model system will then be applied to real world transportation networks to demonstrate its feasibility and applicability. Also, the integrated model prototype will be distributed under open-source licensing agreements.