Integration of TRANSIMS with the ADAPTS Activity-based Model

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ABSTRACT:
While travel demand and traffic assignment models become more and more mature, and while each model is highly dependent on the other one, a real dynamic integrated model has not been implemented yet. The work that is presented in this paper is an effort toward advancing the state of integration between activity-based models and traffic assignment routines. In this study, TRANSIMS traffic assignment has been integrated with ADAPTS, a dynamic activity based travel demand model developed for the Chicago region. Despite other integration studies, the most updated LOS from the DTA model is used in updating activity plans and schedules during the simulation. The model generates travel activities of individuals and simulates them on the network while updating activity plans and schedules at the end of each interval using updated network condition.

1. INTRODUCTION

Traditionally travel demand and supply studies have been conducted in aggregate levels using a four-step travel demand model process. However, due to disadvantages of 4 step modeling approach, Activity Based Models (ABM), which study the supply side and are at disaggregate level, have drawn researchers attentions in the past few years. Meanwhile, many traffic assignment models have been developed for studying the supply side. During the past decade, both demand and supply models have improved, but mostly separately. That is, ABMs do generate disaggregate information of people's travel activities, and traffic assignment models do generate trajectory of individual agents but these two models usually do not exchange agents' information during their processes. Instead they do it at the end of each iteration.

Although a few integration studies have been conducted in the past few years, the integration framework and model that are presented in current research have some advantages that are explained in this paper. In the following sections, first a background on the traffic assignment and some other integration models are presented. ADAPTS and TRANSIMS are briefly explained next, followed by the integration framework. Conclusion and future work are presented at the end.

2. BACKGROUND

2.1. Traffic Assignment

Traffic assignment is the process by which the demand, generated in the activity planning and scheduling phase in activity based models, is realized on the transportation network for the modeled region. Traffic assignment methods can be categorized into two major categories: static and dynamic.

In static assignment traffic flows and link travel times are assumed to be constant over the analysis period. Failing to adequately model congestion, queue formation, dissipation and spillback and dynamics in traffic flow and network are of the main shortcomings of these models which have been discussed in more detail by many researchers (e.g. Mahmassani et al. 1989).

On the other hand, DTA models try to take into account the dynamics of network flow. These models can be categorized into 2 major groups, analytical models and simulation based models. Due to issues regarding solving analytical methods, simulation based models have become more popular (Transportation Research Circular E-C153, 2011).

Both static and dynamic traffic assignment can be categorized into two groups, Descriptive and Normative. Descriptive models assume agents are rational and selfish, and try to maximize their own benefits (User Equilibrium). Normative models on the other hand, assume that agents choose their route such that the travel cost of whole system is minimized (System Optimal). As UE concepts are more in line with human's behavior in real world, it is widely adopted by researchers and traffic assignment software.

Simulation based models can be divided into three categories, depending on the flow representation and fidelity of time and space. Microscopic models (e.g. AIMSUN2, Barcelo et al., 1996) simulate individual vehicles and interaction between them, and move them in a continuous space and over relatively small unit of time (practically continuous). Macroscopic models (e.g. METANET, Messmer et al.) on the other hand, do not deal with individual vehicles; instead they use a fluid representation of flow in discrete time and space and use exit functions to propagate vehicles on the network. Mesoscopic models (e.g. DYNASMART, Jayakrishnan et al., 1994) are similar to microscopic models in terms of simulating individual vehicles, but they tend not to simulate all activities of vehicles or all interactions between them. Mesoscopic models, due to their computational efficiency and performance, have drawn much attention in recent years.

2.2. Integrated Models

The integration of landuse, travel demand and traffic assignment models has received more attention recently due to the maturity of the models and growing computing power (e.g. Hao et al., 2010, Castiglione et al., 2010, Lin et al., 2008). Several activity-based models have recently been integrated with dynamic traffic assignment routines. Castiglione et al. (2010) integrated DaySim (an activity based travel demand model for Sacramento) and the TRANSIMS router (a DTA model), and after calibration, validated it against SACSIM regional travel demand model results and against observed data.

Lin et al. (2008) also integrated the Comprehensive Econometric Micro-simulator for Daily Activity-travel Patterns (CEMDAP) model with the Visual Interactive System for Transport Algorithms (VISTA) simulator. In their framework, CEMDAP generates the travel activities and then the aggregate OD matrix is fed into VISTA. The convergence of the framework is presented as a fixed-point problem. Therefore the LOS extracted from VISTA was compared against CEMDAP input to decide whether the network arrived at convergence. Miller et al. (2003) interacted the Travel Activity Scheduler for Household Agents (TASHA) with EMME2 (a static traffic assignment model) and later on Hao et al. (2010) integrated TASHA with MATSim and used the integrated framework to estimate light duty vehicle emissions. Pendyala et al. (2010) are working on a multiyear research project called simulator of travel, route, activity, vehicles, emission and landuse (SimTRAVEL) that integrates landuse, activity-based travel demand and

DTA models. This model will be tested for the Puget Sound and Maricopa County (Greater Phoenix).

3. ADAPTS ACTIVITY-BASED MODEL

The Agent-based Dynamic Activity Planning and Travel Scheduling (ADAPTS) model, is a new activity-based travel demand model which has recently been developed (Auld 2011) to demonstrate the direct integration of travel demand modeling with traffic assignment. The fundamental concept underlying the development of the ADAPTS model is to treat activity planning and scheduling events as individual discrete events within the overall simulation framework. Consequently, an activity is created and modified over time and eventually executed (i.e. assigned to the network) in one unified simulation. The model is dynamic in the sense that activities are generated and passed to the network assignment as they are scheduled, rather than pre-defining daily activity schedules for agents to assign at one time. This allows for dynamic interaction effects within the demand model and network simulator, including such things as opportunistic scheduling, en-route replanning, etc., which cannot be handled using loosely coupled models. The overall framework of the integrated ADAPTS model is shown in Figure 1.

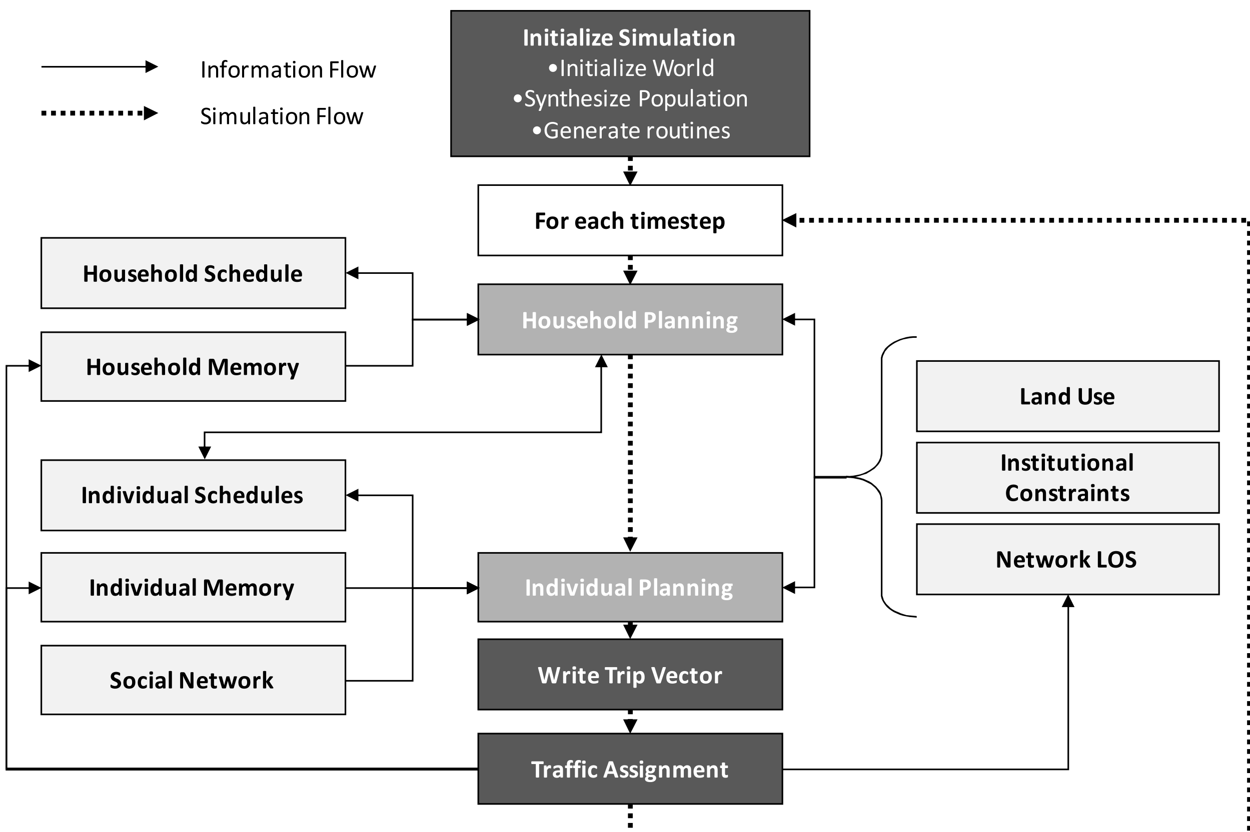

Figure 1. ADAPTS Simulation Process Framework (Auld, 2011)

3. TRANSIMS MODEL

The Transportation Analysis and Simulation System (TRANSIMS) is a set of tools that are used to conduct travel studies. TRANSIMS was originally developed by Los Alamos National Laboratory and includes population synthesizer, activity generator, router and Microsimulator and many other tools that are mainly developed to prepare the input and output data. It not only can synthesize the travel demand, but also its router and microsimulator can be used to analyze the demand impact on the network and generate time dependent link volumes and travel times.

In this study, the TRANSIMS demand generator is substituted by a more advanced and dynamic ABM, ADAPTS. That is, travel activities generated by ADAPTS are fed to the TRANSIMS traffic assignment module.

The TRANSIMS microsimulator, like many others (e.g. VISSIM) employ car following, lane changing, and gap acceptance formulations to move vehicles on the network. Microsimulators are usually used for analyzing spatially small projects, such as a ramp or intersection. Traditionally they use some rules to route the vehicles on the small network, but the TRANSIMS microsimulator design and its computational efficiency, makes it a suitable tool for regional transportation analysis. For this purpose the TRANSIMS router could be used to generate route choices for trips and then microsimulator could be used to accurately estimate travel times.

4. INTEGRATION OF TRANSIMS WITH THE ADAPTS MODEL

There are a few studies in the literature of ABM and DTA models integration, but to the authors' knowledge, none of them represents a real integration. That is, they usually generate trips for a whole day and feed them to the assignment model and then update the LOS information at the end of the assignment process. Then repeat this process iteratively until convergence criteria is met. But this process does not reflect how humans usually behave. In the real world, people revisit their schedule continuously during the day and update it when necessary.

Unlike many other ABMs, ADAPTS has the capability of updating schedules during the analysis period. To the author's best knowledge, none of the developed DTA models is ready for handling within-day replanning. Those which are designed well enough to handle this (e.g. TRANSIMS, MATSIM and AIMSUN), require major changes to the source code. Therefore ADAPTS and TRANSIMS were selected for demand and supply analysis. It is worth mentioning that the authors also are in the process of integrating ADAPTS with AIMSUN and MATSIM.

To make the programming of the integration module simple and as much independent (of future updates to the demand and/or supply models) as possible, the authors decided to integrate the two models through exchanging files. Although one may think that models are not truly integrated unless they are hard coded to work with each other, the reality is that as long as they exchange agents' information at each timestep, it is a true integration. Although hard coding makes the run time faster, it makes the maintenance and future updating much more difficult. The input and output of software are much simpler to understand and interact with.

For designing the integration framework, the authors carefully studied both models and designed the integrated framework (Figure 2). As it can be seen in the picture, after the ABM is run it generates travel activities (trips) at the end of each timestep (e.g. 15 minutes). Trips are then fed to the router to generate travel plans (paths). Plans are then fed to the microsimulator which is waiting for input trips. At each timestep, the microsimulator outputs the latest OD travel times, and the estimation of time to destination for each vehicle. This information is fed to the ABM so it can generate trips that will depart during next timestep. Meanwhile, it updates the destination of those agents who have decided to change their destination. For example if somebody has left his office for a meeting but during the trip finds out that he could not reach the meeting due to congestion, may decide not to continue that trip.

Meanwhile, as the router is executed for each 15 minutes to generate travel path of those who will depart in next 15 minutes, its network should be preloaded with vehicles that are already on the network (information exists in the microsimulator). Therefore each time a router is run to generate travel plans (paths) for newly generated trips the last position of previously departed vehicles, which is already loaded to the microsimulator, along with the newly generated trips are loaded to the router, so it can simulate the real condition of the network. The integration framework is presented in Figure 2

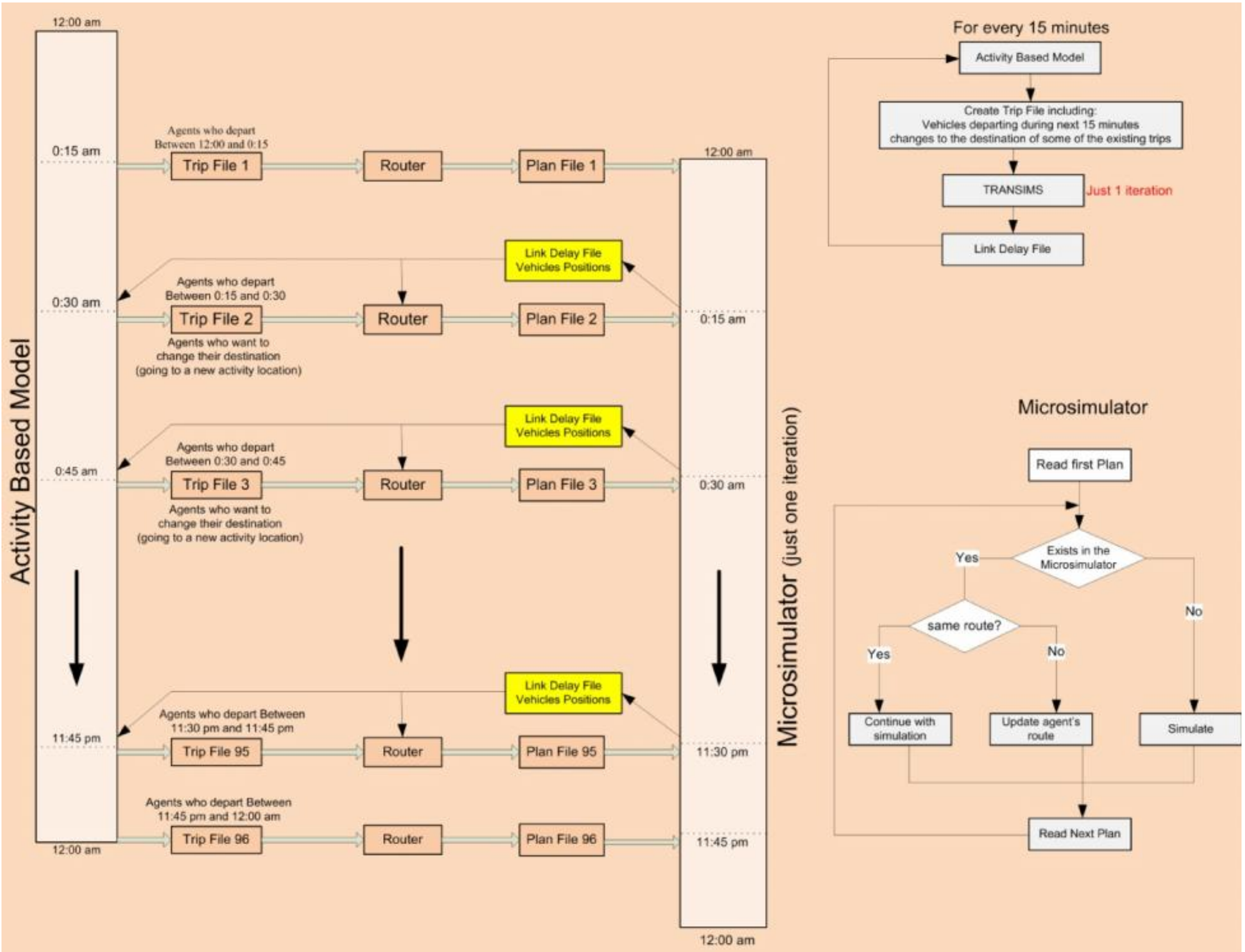

Figure 2. Integration Model Framework

7. CONCLUSION AND FUTURE WORK

In this paper, the integration of an ABM and a DTA model were discussed. ADAPTS which is an advance dynamic ABM was used to generate travel activities, and the TRANSIMS router and microsimulator were used for traffic assignment. As the information of agents on the network is fed back to the ABM at the end of each timestep, it can update agents' schedules (depending on network condition) and reroute them if necessary. Exchanging information at each timestep and taking advantage of this latest network condition to update agents plan during the simulation distinguishes this integration from similar studies. Meanwhile, smaller timesteps make integration more accurate.

As future work, the authors are planning to study various policies, including road pricing policies using the integrated framework. Meanwhile, reliable convergence criteria should be developed if user equilibrium is sought over different iterations. The inclusion of transit simulation, as well as the inclusion of additional motorized and non-motorized modes in the simulation, would improve the traffic simulation results. Additionally, the model can also be extended to include more detailed representations of external and truck traffic, rather than relying on the fixed volumes from the regional travel demand model.

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