Innovations in Travel Modeling 2010

Title:
Issues and Challenges Integrating Activity-Based Demand Models with Dynamic Traffic Assignment Procedures

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Abstract:
Activity-based travel demand models have been implemented in a significant number of regions, but in virtually every case the detailed activity patterns are converted to standard trip tables for relatively large time periods in order to load the demand to the network using traditional static assignment procedures. This throws away all of the details about the relationships between trips in the travel tours and ignores the impacts of the time specific network performance on tour feasibility. Of course, in most of these activity-based models the network performance data used to develop the tours is estimated by the same static assignment techniques. These techniques use volume-delay functions to convert time period volumes and capacity estimates to link travel times. These travel times are used to summarize the zone-to-zone travel conditions for each time period.

Dynamic traffic assignment procedures are rapidly becoming the preferred method for more realistically modeling the time-dependent nature of travel on transportation networks. Integrating these more detailed assignment techniques with activity-based demand models is needed to consider the interaction of network operations and performance with behavior that affect activity patterns, travel schedules, and the choices of mode and/or destination. This integration, however, raises a number of issues and challenges to the overall modeling and convergence procedures. This paper will outline many of the challenges AECOM faced in integrating a variety of activity-based demand models with dynamic traffic assignment procedures. Experience integrating the TRANSIMS activity model in Portland, Oregon, the MORPC activity model in Columbus, Ohio, and the DaySim activity model in Sacramento, California and Jacksonville, Florida with the TRANSIMS regional network simulation tools will be discussed.

Model Design

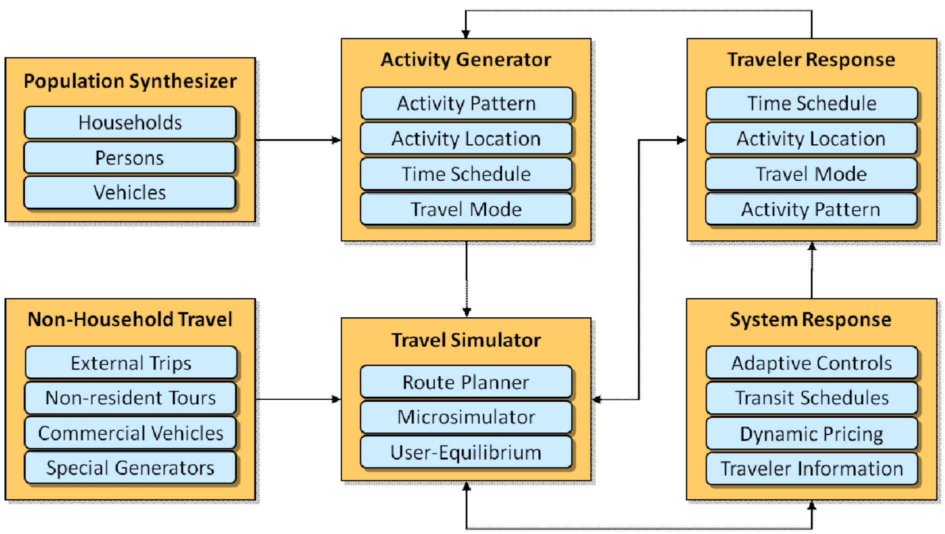
The next generation of travel models must consider the interaction of changes in transportation network operations and performance and the underlying changes in behavior that affect activity patterns, travel schedules, and the choices of mode and/or destination. The tool should include:

- finer resolution of space and time dimensions,
- representation of traveler decisions in the context of household activities,
- representation of the operations of specific streets and facilities, and

- regional simulation of individual vehicles and persons to evaluate system performance.

The ultimate objective of advanced practice travel models is a fully integrated dynamic travel choice and network performance tool. This vision is not limited to the activity-based travel forecasting models, but encompasses the larger vision about how an activity-based demand model fits within the overall need for an analysis tool that models both supply and demand in a consistent and compatible way. Properly integrating advanced supply models with demand models is critical to the success of any advanced model development effort.

The high-level architecture of the dynamic integrated model is shown in Figure 1. The model is first and foremost disaggregate in that it tracks the location of each individual at every second of the day through the complete modeling process. This makes it possible, for example, to model different behavior or perceived value at any point in the modeling process. This is critical for pricing models that estimate a traveler's response to variable tolls based on household income. It also implies that the activity-based demand model is applied within the context of time-dependent networks that include operational sensitivities. This enables the tool to capture the time-of-day effects on travel and realistically evaluate the full range of system and traveler management strategies required by regional planners and decision-makers.



On the other hand, the model makes a clear distinction between fully disaggregate trips and the inter-relationships of household members. The scheduling and coordination of trips have constraints and conditions that depend on the set of activities a household needs to accomplish in a given day given the time and transportation constraints imposed by internal and external conditions. Trips are also combined into tours in recognition of the fact that people make travel decisions based on network conditions and options available for all legs of the tour in total and not each trip independently.

Finally, the model includes a dynamic system response to travel demand. As the system becomes over congested, the system operators may make adjustments to improve system performance. These may be real time adjustments such as adaptive or preemptive traffic controls, ramp metering, congestion-based tolls, and variable message signs, or a general response to recurring congestion such as re-timing traffic signals to improve signal progression or adjusting the transit schedules to reflect actual travel times. This is critical for future forecasting where it is logical to assume the system operators will make reasonable adjustments in response to changing conditions.

Case Studies

Initial efforts to develop models of this type have been completed or are underway in several regions. AECOM lead the effort to develop an activity-based model for Portland, Oregon that is integrated with the TRANSIMS Router and Microsimulator. This application raised many issues and concerns about the effectiveness of activity pattern replication models and the difficulties of locating activities given predefined activity schedules.

Two new studies are underway to determine if other activity modeling methods can be integrated effectively with TRANSIMS dynamic routing and/or regional traffic simulation. With AECOM's assistance, RSG/BBC integrated the TRANSIMS Router with the DaySim activity model in Sacramento. This implementation included dynamic traffic assignment, but it did not include feedback from a network simulation where capacity constraints and traffic controls impact network performance. This interface is currently being expanded by the RSG/BBC/AECOM team as part of the SHRP2-C10 project in Jacksonville, Florida. The enhanced application will include the operational simulation impacts and much tighter integration of the activity model and the simulated travel times between activity locations.

A similar effort is underway in Columbus, Ohio. This project integrates the existing MORPC activity-based model developed by PB with TRANSIMS trip and tour-based simulations. This implementation leaves the activity model as is and replaces the static assignment model with a dynamic assignment model. The overall impacts of changing from a static assignment to a dynamic assignment on model calibration and validation will be of primary concern.

Issues and Challenges

In the TRANSIMS ActGen model, the skeletal activity patterns in the household survey are copied approximately 130 times to populate the synthetic household activities. It is, therefore, crucial that the activity patterns contained in the survey data be as internally consistent and accurate as possible. Analysis of the Portland survey found that 45 percent of the vehicle passenger problems were directly the result of coding or reporting inaccuracies in the household activity survey.

Survey cleaning does not, however, address the time reporting bias inherent in all travel surveys. When the reported times were copied to the activity schedules of the synthetic households, the huge spikes in network demand at specific times of day could not be accommodated by the Microsimulator. This problem was addressed by applying a single random time shift to all activities of a synthetic household. The resulting trip start times were more realistically distributed within half hour time periods which enabled the Microsimulator to effectively load the traffic to the network.

Realistic distributions of trip start times for all households within the region are an important consideration for DaySim and the MORPC activity model as well. The trip start times within a given time period have no impact in a static assignment model, but are significant for a dynamic traffic assignment.

The three activity models that were integrated as part of these projects include various levels of spatial fidelity. The MORPC model uses regional Traffic Analysis Zones, the Portland model used Census block groups, and the Sacramento and Jacksonville models use parcel-level data. In each case the demand data is simulated by the dynamic assignment model using two or three activity locations on each side of each network link. The trips generated by household and non-household activities are modeled at one-minute resolutions and randomly assigned to activity locations and a specific second of the day for simulation purposes.

The applications that used larger zones and collector-level networks had difficulty locating and simulating activities for walk trips. One of the major reasons for this problem was that the zone-to-zone travel time skims did not include adequate intra-zonal details. Additional problems were caused by the allocation process within the destination zone. The theory behind this procedure assumes the trips are motorized and therefore a motorized trip between two nearby zones will tend to be relatively far apart. In other words, if the activity locations were close to each other, the traveler would walk and not drive. If the travel mode is walk, the distribution algorithm should be exactly the opposite. Walk trips will prefer the closest possible activity location.

In addition to walk trips, modeling transit tours within an activity-based model is significantly complicated by the fact that access to transit and transit service levels are not ubiquitous in space or time. This typically means that the number of activities and tours that can be accomplished using transit is relatively limited. For an activity-based model to accurately incorporate these limitations into location or mode choice decisions, extremely fine levels of space and time fidelity are required. Transit trips need point-to-point travel data to effectively select a destination activity location that can be reached in the time available.

The models that use parcel data avoid this problem by including much greater spatial detail in the distribution of population and employment. Unfortunately, point-to-point data is time consuming to generate and store for a large array of potential origins and destinations. Sampling methods and dynamic path building algorithms were introduced into the activity location and mode choice procedures to address this problem. The

TRANSIMS Router was modified to generate travel times to all destinations from a given origin at a specific time of day or travel times from all origins to a given destination at a specific time of day. DaySim, however, wanted the time of day the trip should start from a given origin to arrive at an array of destinations at a specific time. In order to accurately develop this data, a time-dependent path builder needs to build a separate path for each destination.

The initial results of routing and simulating the activities calibrated using average trip lengths were extremely congested. The travel times assumed by the location choice model in scheduling household activities were vastly different from the travel times estimated by the Router using link delays from the trip-based network simulation. Comparing the planned link volumes to traffic counts revealed major discrepancies in the travel patterns generated by the activity generation process and the trip tables generated by the regional model.

It was evident from the time schedule problems in the Router and Microsimulator that the locations selected by the activity generator could not be reached within the allotted time. We attempted to address this problem by adding time-budget constraints to the location choice model. Time budgets measure time available for travel based on the activity schedules.

Time-budget constraints limit the choice of zones available for selection as a destination by the location choice model. A lower and upper bound is applied to the expected travel time to define the range of travel times that will be considered. If a candidate destination zone does not fall within the specified time range, the zone is ignored. This makes the destination that is selected compatible with the activity schedule and less likely to generated time schedule problems in the activity generator or the Router-Microsimulator process.

This process worked well for a single activity between two anchor activity locations. If there were multiple activities between the anchor locations, the process was considerably more difficult. In these cases, some consideration for the diversion from the minimum distance path to locate intermediate activities needed to be considered. The approach that generated the most favorable results limits the diversion from the shortest path between the anchor locations to five minutes per intermediate activity. A schedule penalty is computed for each candidate zone based on the type of constraint, expected travel time (from skims) and the survey schedule. This penalty was added to the total utility for each zone to select the zone that best fits the activity schedule.

A key reason zone-to-zone travel time skims are problematic is that they represent an average travel time without any account for the variance. Since skims measure centroid-to-centroid travel times, the value is reasonably accurate for activity locations in close proximity to the zone centroid. As zone size increases or the distance between zones decreases, the travel time skims will not accurately represent the travel times between random activity locations within the zones. The skims will overestimate or underestimate actual travel times. This biases the location choice probabilities and introduces activity scheduling errors.

To address this problem, zone size adjustment factors were added to the location choice model. The software uses the X-Y coordinates of each activity location to calculate the minimum and maximum X and Y range for each zone. When the location choice model considers a given destination zone, it calculates the straight-line distance between the current activity location and each of the corner points of the bounding box defined by the X-Y range. The distance to the closest corner point is divided by the distance between the zone centroids and saved as the minimum adjustment factor. The distance to the farthest corner is divided by the centroid distance to estimate the maximum adjustment factor. These adjustment factors can then be applied to the zone-to-zone skim to estimate a range of travel times between the current location and potential activity locations in the destination zone.

Conclusions

These projects investigated a number of strategies for implementing activity generation and integrating activity data with time-dependent network simulations. An important lesson learned was that calibrating a location choice model simply based on average trip lengths by trip or leg type is insufficient for ensuring that the activity patterns are temporally or spatially realistic. The shape of the distribution and the capacity of the destination are critical components of the location choice process.

We also found that activity patterns with predefined schedules require some level of time budget constraints to make the coordination of activities feasible for complex tours. In addition, the travel time data used to select locations and schedule activities needs much higher fidelity than zone-to-zone skims can provide. The methods for including zone size factors in the travel time estimation proved useful in overcoming the limitations of zone skims. They worked reasonable well for auto trips, but were inadequate for transit trips. Transit trips need point-to-point travel data to effectively select a destination activity location that can be reached in the time available. Since point-to-point data are time consuming to generate and store for a large array of potential origins and destinations, sampling methods or dynamic path building were needed to make location and mode choice procedures cost-effective.