Trials and Tribulations of High Performance Computing

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Abstract

The next generation of travel models must consider the interaction of changes in transportation network operations and performance as well as 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,
- traveler decisions in the context of household activities,
- 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. It focuses on the 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.

This talk will focus on the computational challenges associated with an advanced practice model and how these challenges affect software development and design. It will reference case studies in Denver, Columbus, Jacksonville, and Washington D.C. where a range of advanced integration efforts have been significantly impacted by computer processing challenges. It will describe how these challenges have been addressed or how they might be addressed by redesigning the software tools or adjusting the computer environment.

Advanced Travel Models

The next generation of travel models must consider the interaction of changes in transportation network operations and performance as well as 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,
- traveler decisions in the context of household activities,
- 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 of 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 throughout the entire modeling process. This makes it possible to model different behavior or perceived value at any point in the modeling process. This is critical, for example, 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.
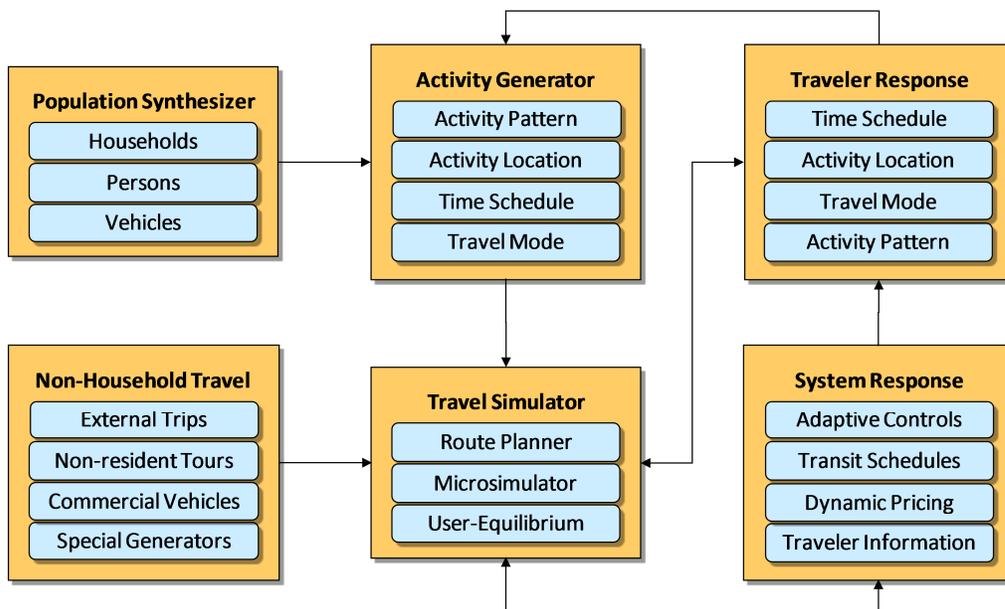
On the other hand, the model makes a clear distinction between fully disaggregate trips and the inter-relationships of household members. The scheduling and coordination of trips have constraints and conditions that depend on the set of activities a household needs to accomplish in a given day given 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 more 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.

State of the Practice

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 discards 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.

In other regions and often for other purposes, traditional static assignment models are being replaced by dynamic traffic assignment or traffic simulation procedures. These procedures are rapidly becoming the preferred method for more realistic modeling of the time-dependent nature of travel on transportation networks for operational and system performance analysis. This modeling is important for optimizing system throughput and reducing delays through operational or design improvements at key bottleneck locations. It is also useful for estimating the impacts of highway, transit, and pedestrian interactions on shared facilities.

Unfortunately, the travel demand used in most dynamic assignment procedures is often fixed or manually adjusted using simplistic assumptions. This ignores all of the behavioral responses that make the demand dynamic. Dynamic assignment techniques need to be integrated with activity-based demand models to realistically consider the interactions 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 procedures.