Field Test of a New Road Traffic Assignment Tool

PROBLEM
Urban transportation planning practitioners routinely perform analyses of selected road segments to identify the origins and destinations of users of proposed improvements. Other analyses depending upon route flows and multiple-class link flows are atmospheric emissions and environmental justice analyses. A problem with such analyses is that the flows on which the analyses depend are not uniquely determined by standard user-equilibrium road traffic assignment procedures, even though total link flows are uniquely determined, subject to convergence errors. One way to determine route flows and multiple-class link flows uniquely is to add an assumption of proportionality to the assignment procedure. This assumption states that the proportions of flow on alternative route segments with equal costs are the same for all drivers, regardless of their origins or destinations. Without this assumption, the proportions of flow on a pair of alternative route segments between one OD pair could be completely different from the proportions of flow on the same pair of route segments for another OD pair. Analyses based on such flows should be used with caution.

APPROACH
Traffic Assignment by Paired Alternative Segments (TAPAS), a new traffic assignment algorithm developed by Dr. Hillel Bar-Gera, offers the first practical way to address this issue. In a project undertaken with Federal Highway Administration support, a field test of TAPAS was undertaken by a team led by Professors David Boyce and Marco Nie. Six practitioners in planning agencies and consulting firms analyzed how route flows and/or multiple-class link flows generated by TAPAS compared with those found by their commercial software systems.

One assignment method, the link-based, linear approximation (Frank-Wolfe) method gave results roughly similar to TAPAS for select link analyses. The number of origin-destination (OD) pairs using a selected link in the link-based solution, however, was typically much higher than in the more precisely converged TAPAS solution. High computation times, or use of multiple processors, to obtain a sufficiently precise solution are costly limitations of such tools. Even so, the findings suggest that link-based tools do provide approximately valid solutions, if solved to adequate precision, a property not realized before this project.

An example comparing the results of the Frank-Wolfe (FW) method and TAPAS is shown below. The selected link is a secondary arterial, southbound Harlem Avenue, about 10 miles west of the center of the Chicago region. The link's capacity is 2,000 vehicles per hour (vph); its free-flow speed is 28 mph. For morning peak period conditions, TAPAS found a total flow of 1,909 vph between 4,752 origin-destination zone pairs, whereas a generic FW code found a flow of 1,989 vph between 8,630 zone pairs. In this traffic assignment model, the region consists of 1,790 zones, of which about half are one square mile in area. The road network is represented by 13,000 one-way links. The total origin-destination flow is 1,430,000 vph, including both cars and trucks. Because they are distributed over more than three million zone pairs, the flows are represented by decimal values, often less than 1.0.

FINDINGS
The upper figure compares the TAPAS (x-axis) and FW (y-axis) solutions. The FW solution is rather approximate, typical of solutions used in practice (14 iterations; relative gap = 1E-2). The TAPAS solution is very precisely converged, which is practical for this new method (relative gap = 3E-16). As shown, the large OD flows agree for the two methods, but the smaller flows are substantially different. These differences are shown more clearly in the lower figure by a log-log plot. The vertical bar on the left side of the figure represents small flows found by the FW method, which are zero in the TAPAS solution. A FW solution with a relative gap of 1E-4 showed slightly less scatter, but had the same number of OD pair.
Field Test of a New Road Traffic Assignment Tool (continued)

MORE
Research on the properties of the solutions generated by TAPAS is ongoing at Northwestern University, Ben-Gurion University of the Negev, and collaborating institutions. The properties, design and performance of TAPAS are described in a paper by Dr. Bar-Gera published online in Transportation Research, Part B, in January 2010. A report describing the findings, Field Test of a Method for Finding Consistent Route Flows and Multiple-Class Link Flows in Road Traffic Assignments, may be downloaded by clicking on “Field Test Report” under Downloads at http://translab.civil.northwestern.edu/nutrend/.