New Developments in the Application of Static and Dynamic Traffic Assignment in Practice

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Introduction

Traffic assignment (either static or dynamic) is at the heart of virtually every transportation project evaluation study, providing a bridge between proposed project scenario inputs/parameters and network performance forecasts. The outputs of traffic assignment models inform us of link traffic levels, network capacity utilization, queue lengths and delays, providing an objective basis for evaluating project benefits, comparing returns on investment, and prioritizing infrastructure projects. All the above is predicated on obtaining sufficiently accurate assignments that can be trusted to represent driver behavior, diversion rates, network response and their various complex interactions. We discuss several recent studies and advances towards better understanding the convergence requirements for traditional assignment, and guidance for successful dynamic traffic assignment (DTA) model deployment using large, real-world case studies.

Importance of convergence in static traffic assignment

Static traffic assignment (or simply traffic assignment) has formed the bedrock of network models for decades. Yet, deployed assignments are often not converged sufficiently enough to allow robust comparison of scenarios. Simple tests can reveal artificial and counter-intuitive effects when assignments are not run to a sufficiently low relative gap, the measure most often used to quantify the distance from a perfect equilibrium solution. Figure 1 underscores the artificial network flow differences at different convergence thresholds, all relative to a highly-converged solution reaching a gap of 1E-15:

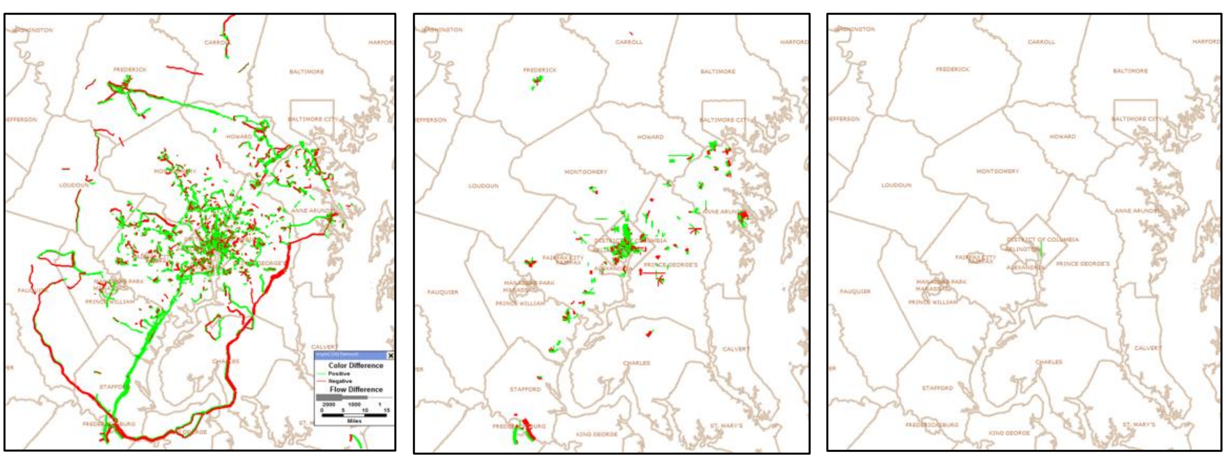

Figure 1: Flow differences at relative gaps of 0.01, 0.001 and 0.00001

Highly-precise traffic assignment algorithms promise to deliver the levels of convergence required in practice, but are generally not possible with older algorithms like Frank-Wolfe. These advances include Origin-Based Assignment (OBA), Path-Based User Equilibrium and N-Conjugate User Equilibrium.

However, a comprehensive battery of tests spanning five real-world, deployed planning models leads Slavin et al. (2015) to conclude that the state of the practice is yet to catch up with the state of the art.

An encouraging assessment from the above study is that most existing assignments can be tightened with relative ease by simply migrating to more advanced algorithms, and/or adopting stricter convergence metrics and thresholds. Planners should be wary of multiple mathematical formulations for metrics like the relative gap, not all of them indicating the same accuracy for a given convergence threshold. Practitioners also often set sub-optimal convergence parameters in the interest of run times. This approach needs to be revised based on continuous hardware and software evolution that pushes the frontiers of computational efficiency.

Figure 2 demonstrates the impact of utilizing more "cores" in modern processors, with solution quality improving orders of magnitude for the addition of just a few more cores. Such speed-ups are possible when software engineering effectively harnesses the available hardware resources through multi-threading, parallel processing, etc., making them practical for even models at the regional scale.

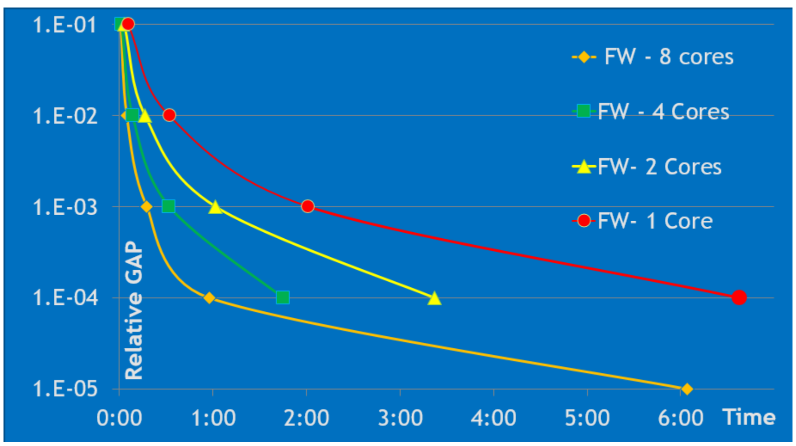

Figure 2: The benefits of multi-threading (Frank-Wolfe assignment)

Addressing the challenges of large-scale dynamic traffic assignment (DTA)

DTA captures the ebb and flow of traffic over short time periods typically 5 to 30 minutes long. At a dynamic equilibrium, travelers departing their trip origins ***in the same short time period*** cannot improve their travel times by switching routes. DTA can potentially capture queueing and spillback dynamics, delays, and the operation of complex traffic control techniques. DTA can also handle a range of driver and travel behaviors through choices of lane, toll facilities, routes and trip departure times.

Successful DTA applications are challenging in practice, requiring models of individual vehicles and the behaviors of their drivers. Such complexity necessitates simulation techniques that brings with it a host of concerns including network development effort, model fidelity (microscopic vs. mesoscopic), model running time, scalability, calibration data requirements, stochasticity, and convergence. We present two case studies to prove that these challenges can all be addressed today.

Case study 1: Phoenix

A DTA model based on microscopic network loading was developed for Greater Phoenix, Arizona, covering 1360 square kilometers. A lane-level network was developed from the local planning model's center-line network and aerial imagery. Signal plans for about 1800 intersections were obtained and coded/imported. Origin-destination (O-D) flows by 15-minute departure intervals were calibrated to match directional traffic counts, while speeds were used to infer bottlenecks. Congested travel times were estimated through a DTA, and iterated to improve model fit. A sample of the model's accuracy is shown in Figure 3. This model is currently being expanded to a state-wide, multi-county scope at the same microscopic fidelity, while subarea models are already deployed to evaluate future project scenarios.

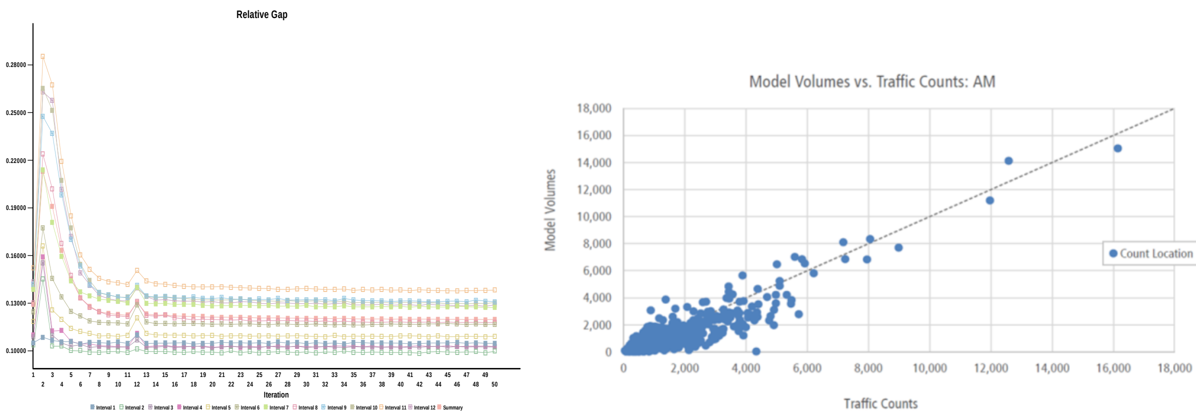

Figure 3: DTA convergence and fit to traffic counts (Phoenix, Arizona)

Case study 2: Colorado managed lanes

A very different DTA application was implemented along the C-470 freeway corridor in Colorado, to predict the utilization of (and revenues from) proposed dynamic toll facilities. With limited route choice options along parallel arterials, the case study is ideal for isolating the toll facility choice behavior of drivers for lengthy trips, and conducting sensitivity analysis on the trade-offs between congestion relief and willingness to pay.

The highway network was modeled in microscopic fidelity, and time-varying count data at critical mainline and ramp locations were used to calibrate the baseline O-D demand. Survey data were used to estimate value of time distributions, which were introduced into the model to study the impacts of various toll strategies.

Conclusion

The accuracy of traffic assignments is critical to their utility in real-world evaluations. We highlight recent research that rigorously documents the artificial impacts of insufficiently converged static assignments, and discuss advances that can resolve the gap between research and practice. We also illustrate the aptness of simulation-based dynamic traffic assignment, especially those based on traffic microsimulation, to answer today's pressing traffic operations questions, and demonstrate that the approach is indeed ready for large-scale adoption.

References

1. H. Slavin, J. Lam and K. Nanduri (2015) "Traffic Assignment and Feedback Research to Support Improved Travel Forecasting." Project final report prepared for the Federal Transit Administration.