ABSTRACT

Kumar, Amit. Ph.D., Purdue University, May 2014. Path-Based Traffic Assignment Algorithms and Models to Enhance Deployment Robustness. Major Professor: Srinivas Peeta.

The domain of traffic assignment algorithms has been an active area of research for more than five decades and still continues to be so for two important reasons. First, it estimates traffic flow pattern and determines the levels of service, and help in predicting the need for improvements in the transportation network. Second, estimated traffic flow pattern forms the basis for cost benefit analysis, and helps to decide the best alternative of network improvement. Static deterministic Wardropian user equilibrium (UE) is the widely used technique in practice for solving the traffic assignment problem (TAP) due to its simplicity in implementation and modest data needs. But, there are three issues related to UETAP algorithms namely, solution stability, consistency and convergence which are problematic from both theoretical and practical perspectives. In addition to this, UE condition is not sufficient to determine path flow solution uniquely and multiple path flow solutions are possible with large variations. These issues related to UETAP raises questions of confidence in the comparison of alternatives based on the UETAP solution outcomes. This research proposes path-based traffic assignment algorithms and models that endeavor to achieve the deployment robustness. This research also proposes a post-processing technique that incorporates these algorithms and models into the widely used four-step planning process using a feedback loop. The deployment robustness here is characterized by three important model properties namely, the solution stability, consistency and stable convergence. The solution stability here implies that small changes in input to the model lead to small changes in model output. The consistency implies that the model output in terms of network flows reasonably reflects the changes in the input. The inconsistency in path flow solution of traffic assignment problem can arise due to two reasons; first, the solution noise and second, the non-uniqueness of solution which is an inherent property of path-based traffic assignment formulation. This research proposes a model to identify a single path-flow solution from the solution space that is representative of entire solution space. The proposed model seeks to identify the single path-flow solution in the form of entropy weighted average of all possible solutions. This solution has the minimum expected deviation from all possible solution points in the solution space; hence it is a better representation of solution space. This solution is also theoretically stable. Proposed method overcomes the theoretical limitations of maximum entropy based approach for finding the most likely path flow solution proposed in past. In addition, the proposed model is easier to implement for practice. The proposed model needs precise UE link flows and set of UE paths. This research develops two path-based algorithm for generating the UE link flows and UE path set. First algorithm is labeled as slope-based multi-path algorithm (SMPA) and has

been developed to achieve stable convergence. Further, a hybrid version of SMPA is developed by combining the merits of sequential approach and simultaneous approach of solution algorithms. This hybrid approach facilitates applicability to large size networks and tends to eliminate order-bias in the solution. The order-bias can be a potential reason for solution noise leading to inconsistency in solution. The second algorithm labeled slope-based path shift-propensity algorithm (SPSA) inherits merits of SMPA-hybrid and endeavors to incorporate behavioral consistency in the flow update process. SPSA is simpler to implement and can act as potential substitute of SMPA for practice. In addition, this research proposes a day-to-day (DTD) dynamical model to represent the path-shift behavior of network users under the disequilibrium of traffic networks. Path-flow evolutions from this model can be used to evaluate the impact of transportation intervention projects and to mitigate their impact using strategic management. There are two key aspects of this model that bridges two important gaps in literature in this domain. First, it introduces the concept of variance band. The variance band allows modeling the variation in the perception of drivers shifting paths. Second, proposed model incorporates the sensitivity of path costs with respect to flows in modeling the DTD dynamics. These two factors help to enhance real-world consistency in the modeling and smoothens the trajectory of flow evolution profile. Contributions of this research are important from both theoretical and practical viewpoints. In the theoretical context, it formulates two efficient path-based solution algorithms for traffic assignment, presents a model for determining a single representative path flow solution from the multiple possible solutions of UETAP and develops a dynamical model to represent the path-shift behavior of drivers under traffic disequilibrium. These algorithms and models aim to attain stable and faster solution, and endeavor to bring behavioral realism in the flow update process. For practice, these algorithms and models can be used to obtain a more stable and consistent solution with a high level of precision and promise to improve the reliability of traffic assignment based analysis in the planning process.