Integrated Framework of Departure Time Choice, Mode Choice, and Route Assignment for Optimal Design of Time-Dependent Transit Pricing Strategies

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Abstract

Modern travel demand management strategies, such as time and distance-based congestion pricing (road tolls and transit fares), active traffic management strategies (managed/smart lanes), and road space rationing, require evidence-based quantitative assessment to measure the potential effects on the transportation network performance and people’s responses to the dynamic consequences of such applications. This thesis focuses on building an integrated framework of departure time choice, mode choice, and dynamic multi-modal route assignment for optimal design of travel demand management strategies applied to large-scale multimodal transportation networks, with the focus on time-based transit infrastructure pricing, applied to a case study in Toronto. The proposed platform integrates a simulation-based dynamic multi-modal multi-user-class route assignment model with an econometric model that jointly estimates departure time and mode choices, and genetic algorithms optimization.

As a use case, the proposed integrated platform has been used in analyzing and optimizing time-dependent transit fares as a potential strategy to manage peak-hour transit crowding. Considering the traffic and transit networks as one system, the objective is to minimize travel times as well as
congestion (crowding) during peak periods by influencing travellers to alter their choice of transport mode, departure time, and/or route. The anticipated effect is to pace and spread out demand across space (modes and routes) and time (peak vs. peak shoulders) to yield the optimal spatio-temporal distribution of demand that minimizes end-to-end travel time and congestion. The control variables are the time-dependent transit fares, which are to be optimized while capturing the cross-effects between traffic and transit networks. As a large and realistic use case, a model of the Greater Toronto Area has been developed to demonstrate and validate the results of this research.

The main contributions of this research include: (1) developing a simulation-based large-scale dynamic traffic and transit assignment model that captures the interactions between the traffic and transit sides; (2) integrating the dynamic route assignment model with a joint econometric model of departure time and travel mode choice to build a comprehensive model (the METRO platform) that can be used to assess dynamic travel demand management strategies; (3) integrating the METRO model with a cloud-based genetic algorithm engine to enable optimizing the design of travel demand management policies with emphasis on transit fares; and lastly (4) analyzing and optimizing time-dependent transit fares in Toronto to minimize average weighted door-to-door travel time of all individuals in the system using all driving and transit modes, and quantitatively assessing the impact of the resulting time dependent transit fare as a policy and its strengths and weaknesses in addressing transit crowding.