Bi-objective Traffic Assignment with Multiple User Classes: A Time Surplus Approach

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Abstract

Traffic congestion is an issue in most cities worldwide. One way to model and analyse the effect of congestion on route choice behaviour is traffic assignment (TA). Conventional TA models the behaviour of travellers by assuming that all drivers are selfish and tend to choose the fastest routes from their origin to their destination. As a result an equilibrium state is achieved, when no one has an incentive to switch to another route. Therefore, it is assumed that all drivers make their travel decisions regarding travel time only. However, this is not true in general. According to empirical studies other important factors are travel time reliability and monetary cost.

In the literature on the TA problem where two or more objectives are explicitly distinguished the majority of the models form a weighted sum of the objectives. This approach is not general. It allows to find only a subset of all equilibrium solutions. We propose to use a conceptually different approach - the bi-objective user equilibrium. It considers two objectives separately (travel time and toll) and allows multiple solutions. In order to model user preferences, we apply the time-surplus maximisation model (TSMaxBUE) which can identify one of the solutions.

Time surplus is defined as the maximum time a user is willing to spend minus the actual time spent. The maximum time a user is willing to spend is modelled as an indifference curve - a non-linear function that depends on the path toll. All drivers are divided into classes with different indifference curves that model preferences of each group. We show that this model admits a mathematical programming formulation and we adapt some conventional TA algorithms to solve TSMaxBUE with multiple user classes. The TSMaxBUE model allows to obtain various traffic patterns by changing the indifference curves. We observe that this framework is general enough to cover any situation with a flow dependent and a flow independent component of path cost.