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**BOOK OF ABSTRACTS**

# **Improving the Performance of a Traffic System by Fair Rerouting of Travelers**

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**Abstract.** Traffic authorities implement management measures to route drivers towards socially-desired paths. The main goal of such measures is to steer the network from the inefficient but fair user equilibrium to the system optimum: the traffic state that minimizes total travel time (Wardrop, 1952). Here, the behavioral response to route advice is often not accounted for, since some drivers are advised to take a significant detour for the system's benefit. Hence, these drivers may not comply with such advice, and the optimal state will not be achieved. However, empirical evidence shows that (some) users are receptive to advice that proposes reasonable routes that benefit the system (van Essen et al., 2020).

In this study, we propose a social routing service that steers the traffic network towards an efficient but also fair, and, therefore, attainable and over time maintainable traffic state. This social routing system anticipates user responses: only a portion of the demand is assumed to receive and follow the advice, and the realized travel time difference among travelers is explicitly limited.

Although empirical research shows that social routing has great potential in real life, there are theoretical challenges to be addressed before implementation. It is not yet known which paths to propose to which type of travelers, and how to efficiently calculate these paths. In this paper, we show that the theoretical challenges can be addressed by formulating and analyzing a bilevel optimization problem. This program calculates the best possible paths to be proposed to receptive travelers (those that use and comply with advice) and limits travel time differences in the resulting state.

A critical issue in solving the bilevel problem is that the lower-level optimal solution is non-unique. We use techniques from variational analysis to show that the directional derivative of the lower-level link flow nonetheless exists. This generalized derivative can be efficiently found as a solution of a quadratic optimization problem but requires a suitable route flow solution as parameter. We provide an auxiliary linear program that finds this path flow solution efficiently.

We use the directional derivative in a descent algorithm to solve the bilevel program. Numerical experiments show that a real-world implementation of the social routing service has the potential to substantially improve efficiency and preserve fairness at the same time. If only 25% of all travelers take a very small detour (less than 0.6 minutes, where a system optimum requires 3.2 minutes), 27% of the maximum-possible savings are achieved.

**Keywords:** Traffic, Social Routing, System Optimum, Network Efficiency, Anticipatory Traffic Control

## **References**

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