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Network design under a discrete choice: a bilevel programming approach

Network design problems fit the Stackelberg game framework. Two types of players are involved: leader and follower. A single leader plays first and has perfect knowledge of the followers' strategy, while the followers only responds to whatever action the leader has taken. In our case the leader's goal is to maximize his revenue by setting tolls and capacities on some of the network links. This forms the basis of the generic revenue management problem. The followers' response will be described by an entropy minimization based discrete choice model parametrise by the leader's policy. This setup is most naturally formulated as a bilevel mathematical program. The resulting revenue maximization problem is differentiable but non-concave and does not directly lend itself to global resolution tools such as the combinatorial techniques often used for network design problem.

We first consider the pricing problem, where capacities are fixed. In order to find good toll policies we formulate and solve to optimality several mixed integer approximate formulations. Approximation schemes involve piecewise linear, or quadratic, approximations of the nonlinear terms involved in the followers' flow distribution. These approaches are combined with local methods taking further advantage of the problem differentiability. Getting optimality certificates on the original problem is in general out of the question. Yet an upper bound is obtained which does give some guaranty of global optimality. The case where tolls and capacities are both decision variables is the focus of the last section of the talk and involves solving a restriction of the problem to a discrete set of candidate capacities.