Solving the Stackelberg problem on networks

Abstract

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In competitive facility location the general aim is to locate one or more new facilities for an existing or a newcomer chain maximizing its market share or profit. When competitors are likely to react with their own expansion, the owner has to take that into account. This leads to a bi-level optimization problem, where the optimal location of the first player, the *leader*, has to be determined depending on the location of the second player, the *follower*, who decides its location with the knowledge of the location of the leader. We suppose that the follower's decision is rational, maximizing their profit. This problem is called the Stackelberg problem.

The underlying location problem depends on many factors starting from the decision space, through properties of the demand till costumer's choices. In this work static competition with inelastic demand is considered. Demand is concentrated in a discrete set of points, called demand points. Costumers are assumed to follow the probabilistic choice for the facilities, i.e. they split their demand proportionally to the attraction they feel to the facilities. Attraction of a facility determined by its quality and the distances to it, through a gravitational type model. The objective function to be maximized is the profit obtained by the chain, to be understood as the income due to the market share captured by the chain minus its operational costs. The location space in our model is a network, with the vertices being demand points and the facilities located on its edges.

The defined model gives a very difcult optimization problem, where the second level itself, the location of the follower, is an NP-hard problem. Indeed, this Stackelberg problem is solved with a reliable method, the well-known Branch and Bound procedure using Interval Analysis and DC decomposition for the bound calculations.