Coverage objective and its generalizations in location analysis

Dmitry Krass

Rotman School of Management, University of Toronto

Coverage is one of the two classical objective functions (along with the median) in location analysis. The idea is both simple and appealing: instead of worrying about exact travel patterns of customers to facilities, we simply focus on whether a particular location configuration ensures that there is a facility sufficiently close to each customer location.

This has both practical and computational appeal: on the practical side, the potential applications range from public service facilities, including emergency facilities, to retail stores. On the computational side, the coverage focus allows for significant simplification of the underlying optimization models.For example, while the $p-$median problem with planar decision space and discrete demand is much more challenging than its discrete counterpart, the planar $p-$cover problem is easily reducible to its discrete version.

A close relative of the coverage objective is "obnoxious cover" or anti-cover, which applies in case of undesirable facilities (such as landfills) where the number of "covered" customers should be minimized. This seemingly innocuous change from maximization to minimization already creates certain complications and undesirable model behaviours that need to be corrected with additional constraints.

The classic coverage objective makes several strong implicit assumptions: (1) coverage is an "all or nothing" phenomenon, i.e., a customer is either covered or not covered, (2) coverage is determined by the facility that is closest to the customer, (3) coverage (or its absence) is deterministic. In recent years models have been proposed relaxing some or all of these assumptions by examining the very idea of "coverage": under what circumstances can we be reasonably sure that a given customer will receive "adequate" service from a certain facility configuration? One of the earliest generalizations was the idea of "gradual cover", relaxing assumption (1). Concepts such as “cooperative cover” and ”multi-cover”, relaxing assumptions (2) and (3) followed. Another extension is that of “robust cover”, ensuring that adequate coverage is maintained even if some parts of the transportation network fail. The price of relaxing these assumptions are models that are significantly more challenging, particularly when the decision space and/or the demand space are not discrete.

In most cases, similar extensions apply to anti-cover versions, often with additional complications.

In this talk we will review both the classical models and many of the extensions, review some exact and heuristic solution approaches, and outline some open problems and directions for future research.