A computational comparison of several formulations for the multi-period incremental service facility location problem

Maria Albareda-Sambola[1], Antonio Alonso-Ayuso[2], Laureano F. Escudero[2], Elena Fernández[1], Yolanda Hinojosa[3], and Celeste Pizarro[2]

[1] Dept. of Statistics and Operations Research, Technical University of Catalonia, Barcelona, Spain
{maria.albareda, e.fernandez}@upc.edu
[2] Dept. of Statistics and Operations Research, University Rey Juan Carlos, Móstoles (Madrid), Spain
{antonio.alonso, laureano.escudero, celeste.pizarro}@urjc.es
[3] Dept. Economía Aplicada I, University of Seville, Seville, Spain
yhinojos@us.es

Abstract

Given a time horizon, a set of customers and a set of potential sites for facilities, the *Multi-period Incremental Service Facility Location Problem* (MISFLP) is concerned with locating facilities within the given discrete set of potential sites and assigning the customers to the open facilities along given periods in the time horizon.

Different types of multi-period facility location problems have been addressed in the literature, since the early papers by Warszawski [7] and Van Roy and Erlenkotter [6], up to the more recent references (see, for instance [4, 5]). Traditionally, in multi-period location problems the customers demand should be satisfied at all time periods. However, in a dynamic context there are potential applications where the full operating capacity of the system need not be achieved until the end of the time horizon. Instead, at intermediate time periods, the service capacity of the system (and thus the number of new customers that can be serviced) is incrementally updated at the same time as facilities are opened. In a recent paper, Albareda-Sambola et al. [2] have proposed the MISFLP to minimize the total cost throughout a finite time horizon while ensuring at each single period t the service of a minimum number of customers, say n^t. In the MISFLP it is accepted that the allocation of any customer to the servers might change in different periods. Nevertheless, once a customer is served (allocated) in a time period it must be served at any subsequent period. Moreover, it is assumed that exactly p^t new facilities are opened in each time period, and that once a facility is opened it remains open until the end of the time horizon. In [2] it is seen that MISFLP is quite general and it has as particular cases problems with apparently different characteristics. MISFLP belongs to the class NP-hard, since it reduces to the well-known p-median problem [2] when the planning horizon consists of one single period.

In this paper we address a variation of the MISFLP where each customer needs to be serviced only in a subset of the periods of the time horizon. In this version, we assume that this set of periods is known for each customer. We present three 0-1 formulations of the model based on the methodology of impulse variables and step variables introduced in [3] in a different context. The first model basically coincides with the model proposed in [2]. An extensive computational comparison is made to assess the performance of the three formulations, and to select the formulation to use in a companion paper [1], where some parameters are not known with certainty (in particular, the set of periods when each customer requires service and the minimum number of customers to be serviced in each time period) and, then, Stochastic Integer Programming is used. The computations have been performed by using a state-of-the-art optimization system.

References

1. M. Albareda-Sambola, A. Alonso-Ayuso, L.F. Escudero, E. Fernández and C. Pizarro. On solving the multi-period location-assignment problem under uncertainty. In preparation.
2. M. Albareda-Sambola, E. Fernández, Y. Hinojosa and J. Puerto. The multi-period incremental service facility location problem. *Computers & Operations Research* to appear, 2007.
3. D. Bertsimas and S. Stock-Patterson. The air traffic flow management problem with enroute capacities. *Operations Research*, 46:406–422, 1998.
4. Y. Hinojosa, J. Puerto and F.R. Fernández. A multiperiod two-echelon multicommodity capacitated plant location problem. *European Journal of Operational Research* 123, 45–65, 2000.
5. M.T. Melo, S. Nickel and F. Saldanha da Gama. Dynamic multi-commodity capacitated facility location: a mathematical modeling framework for strategic supply chain Planning. *Computers & Operations Research* 33, 181–208, 2006.
6. T.J. van Roy and D. Erlenkotter. A dual-based procedure for dynamic facility location. *Management Science* 28, 1091–1105, 1982.
7. A. Warszawski. Multi-dimensional location problems. *Operational Research Quarterly*, 24, 165–179, 1973.