Evolutionary algorithms for a bi-objective

Machines of a bank, post offices, gas stations, internet mirror sites, vending machines, web service providers and the like in a given area where competitors offering the same service have already located their facilities. We can also conclude that research works on multi-objective competitive facility location problem are considerably fewer than the ones in single-objective competitive facility location problem.

Regarding the stated notes, this paper deals with the competitive facility location problem for congested systems in which facilities behave as the M/M/1/k queuing system. The proposed problem is investigated not only from the service provider's point of view, but also from customer's perspective. From the service provider's point of view, the model attempts to maximize the captured demand by each facility. From customer's perspective, the model increases the service level by minimizing the total waiting time at the system. The customer's patronizing behavior is modeled on the basis of gravity function that depends on the quality/reputation of service provider and the travel time to facilities. Since the derived model belongs to the NP-Hard class of optimization problem, two multi-objective evolutionary algorithms, namely multi-objective harmony search algorithm (MOHS) and non-dominated sorting genetic algorithm-II (NSGA-II), are implemented to solve it.

The rest of the paper is organized as follows. The mathematical formulation of the proposed model is developed in Section 2. Section 3 presents the details of the proposed MOHS and NSGA-II. In Section 4, different performance metrics are presented to evaluate the performance of solution procedures. The computational results are illustrated in Section 5. Some conclusions and possible directions for further research are given in Section 6.

2- Model formulation

In this section, a bi-objective competitive facility location problem for congested systems is proposed in which the entering firm wants to locate several facilities in the network, when there is already competitors operating in the same geographical area. It is assumed that customers decide to which facility patronize based on the gravity function. The investment budget for opening and operating facilities are limited. It is also assumed that facilities cannot be operated unless they achieve a minimum workload requirement. The objectives of the problem are to maximize the captured demand by each facility and increasing the service level by minimizing the total waiting time at the system. The sets, parameters, and decision variables are defined as follows:

In this model, the first objective maximizes the captured demand by the entering competitor. The second objective provides the maximization of the service level by minimizing the total waiting time at the system. Constraints (14)–(19) are the definitions of the auxiliary parameters. Constraint (20) forces that customers capture can be only by open facilities. Constraint (21) insures that each customer is served by just one facility. Constraint (22) specifies the number of entering facilities to be located. Constraint (23) stipulates that facilities cannot be operated unless they achieve a minimum workload requirement. Constraint (24) limits the investment budget for opening and operating facilities. Constraint (25) forces the stability of the queue. Constraint (26) forbids negative q_{ij} and constraint (27) forces integrality of location variable.

3- Solution procedures

The proposed constrained bi-objective non-linear integer programming model belongs to NP-Hard class of problem and exact methods are inefficient to solve it. Thus, two multi-objective evolutionary algorithms, namely multi-objective harmony search (MOHS) and non-dominated sorting genetic algorithm-II (NSGA- II), are applied to solve the problem.

3-1- Multi-objective harmony search

The harmony search (HS) algorithm, proposed by Geem et al. (2001), is a population-based meta-heuristic algorithm mimicking the improvisation of music players. In the music improvisation process, the members of the music group try to adjust the pitches of the instruments to obtain a better harmony which is analogous to finding global optimum. The details of the proposed algorithm are explained in the following subsections.