Population-Based Algorithm for Discrete Facility Location with Ranking of Candidate Locations

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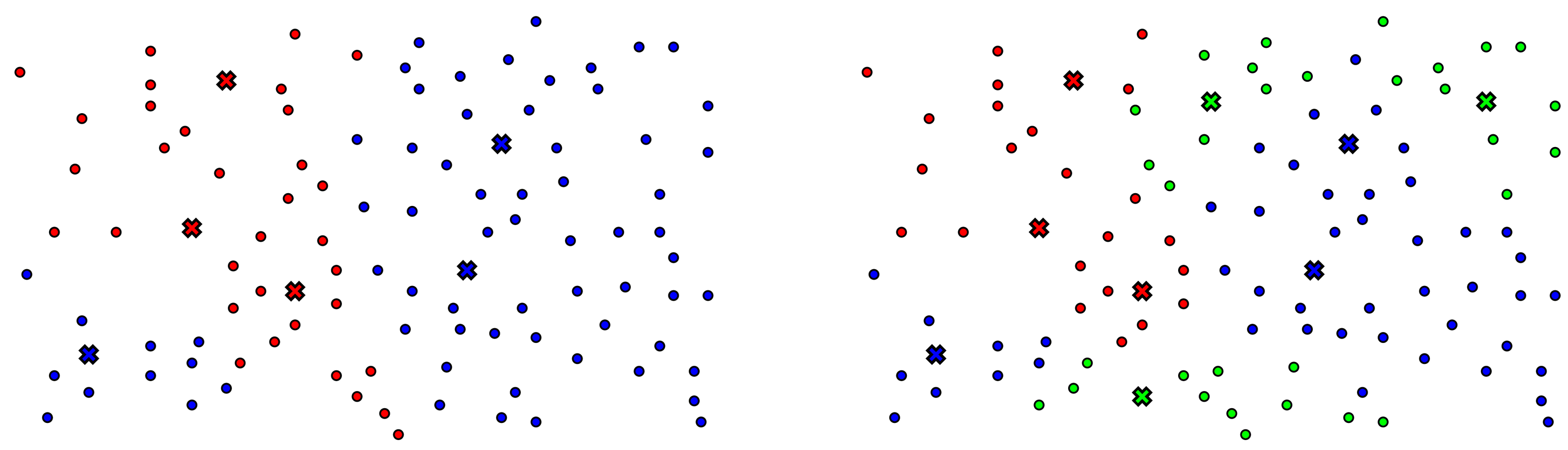
Abstract

This research is focused on the discrete competitive facility location problem for an entering firm, which is important to firms that are entering a market and need to choose optimal locations for their facilities from a predefined set of candidate locations. The goal is to maximize the market share obtained by the new locations, considering the competition from other facilities owned by other firms in the market. A new heuristic algorithm based on the ranking of location candidates and handling of the population of the best solutions found so far has been developed and applied to solve this facility location problem. The algorithm includes strategies to handle the population of the best solutions found so far and strategies for ranking candidate locations. The developed algorithm has been experimentally investigated by solving the discrete competitive facility location problem with the Pareto-Huff customers behavior rule.

Discrete Competitive Facility Location

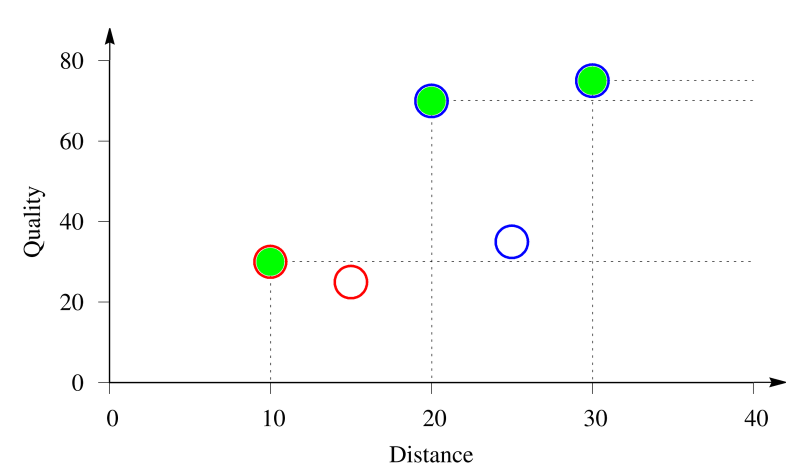
- Firm A has a set F_A of n_A **facilities** and firm B has a set F_B of n_B **facilities**.
- Firm X wants to enter the market by establishing a set F_X of n_X new **facilities**.

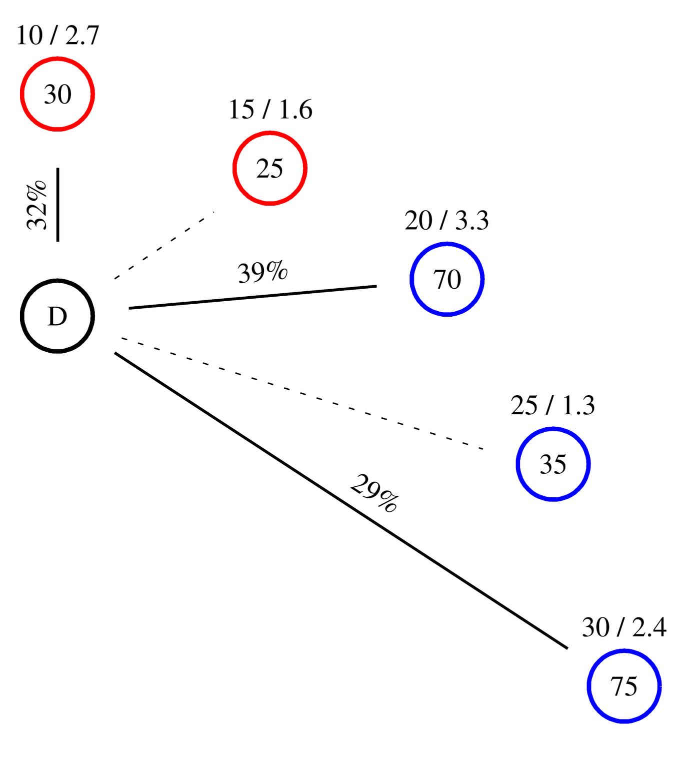


- Firm X faces an optimization problem aimed at maximization the market share of the new **facilities**.
- Locations for the new facilities can be selected from a finite set of candidate locations.

Customer Behavior Model: Pareto-Huff

- The buying power of each demand point is split between facilities that are Pareto optimal by quality of the facility and distance to the facility.





Ranking-based Algorithm for Facility Location

Input: Maximum population size ($maxP$), objective function, stopping criteria and other parameters
Initialize population P with a single initial solution
While termination criteria are not met
  Calculate ranks of the candidate locations
  Select $X \in P$ for generation of the new solution
  Generate the new solution X' and evaluate its fitness
  If X' improves the worst solution in P **then** insert X' into P
  If size of P exceeds $maxP$ **then** remove the worst solution from P
EndWhile
Return the best solution from P

Generation of New Solutions

- The new solution is generated by changing elements of the solution sampled from P.
- Each solution in P has its own probability π_i to be sampled, which is proportional to its fitness - the larger fitness, the larger probability to be selected.
- Each element of the selected solution $X' \in P$ is changed with the probability which is equal to one divided by the number of new locations.
- Each location candidate has its probability to be selected, which is based on the rank of the candidate. Larger rank means larger probability to be selected.

Ranking of the Location Candidates

- The ranks of location candidates are set to 1 at the beginning of the algorithm.
- Consider $N(l_i)$ is the number of solutions in P which contains location candidate l_i:
  $N(l_i) = |\{X \in P : l_i \in X\}|$
- Then the rank of the location candidate l_i is $r_i = N(l_i) + 1$.
  - The lowest value of r_i is 1 and will be assigned to location candidates which do not belong to P.
  - The largest rank value n_P and it means that the candidate belongs to all solutions in P.

Population Handling

- If the newly generated solution X improves the worst solution in P, then X is inserted into P.
- If the size of P exceeds its maximal value max_P, then the worst element of the population is removed.

Numerical Experiments

- The discrete competitive facility location problem with Pareto-Huff customer behavior model.
- The set of demand points represents 589 largest municipalities in Spain has been used.
- Preexisting facilities: 10 facilities located in 10 largest demand points.
- Candidate locations: 500 candidate locations.
- Number of new facilities 3 and 10 new facilities.
- Stopping criteria: 10,000 objective function evaluations.
- All experiments were performed 100 times and average results were analyzed.

Results