Competitive Facility Location Problems with Different Customer Behavior Rules

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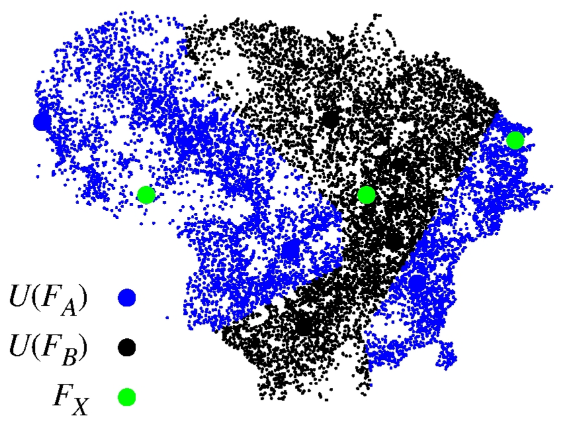
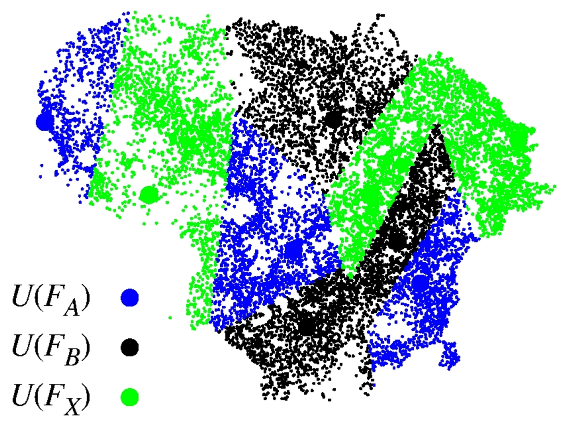
Discrete Competitive Facility Location

- 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.

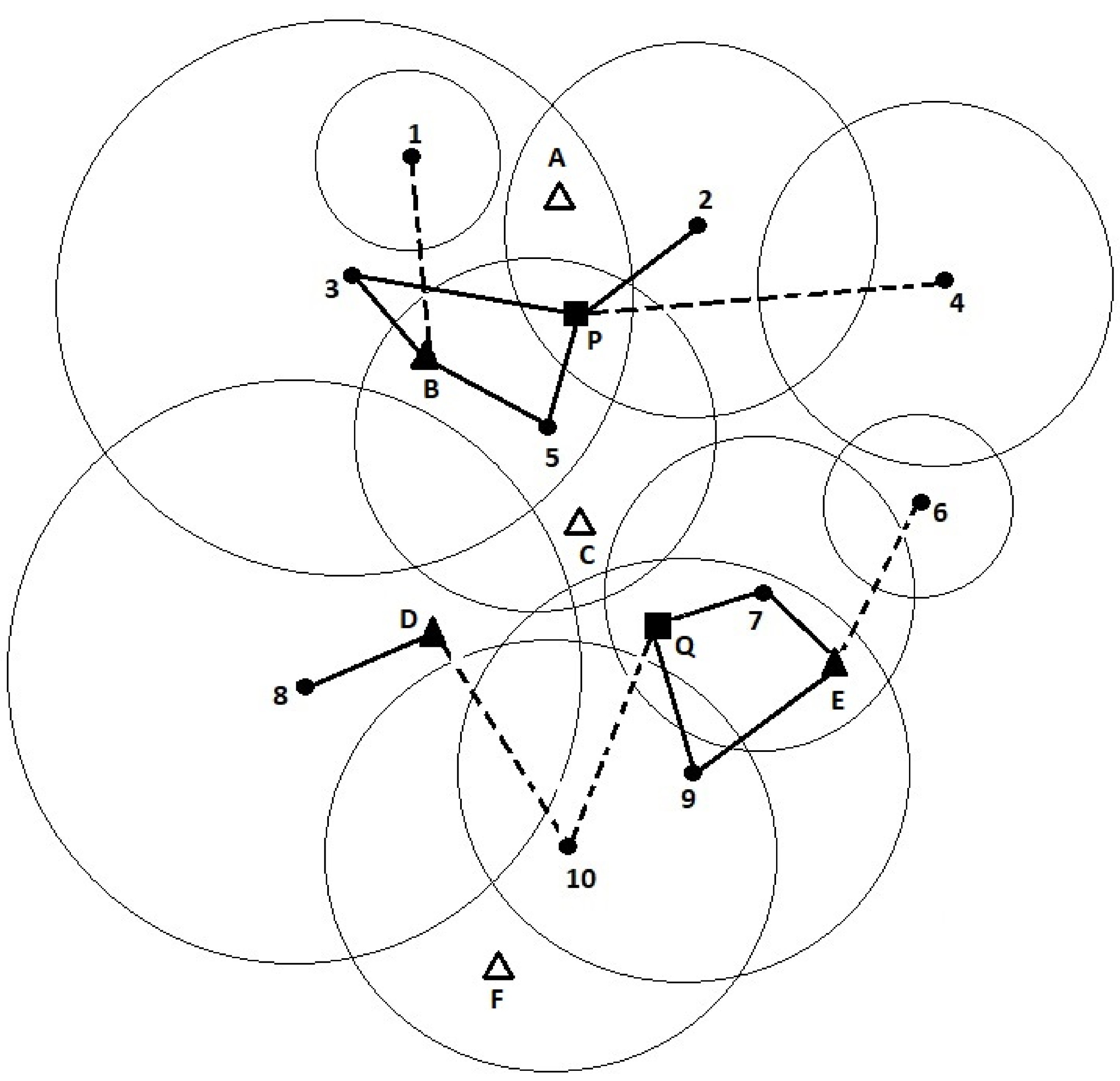




- Firm X faces an optimization problem aimed at maximization the market share of the new facilities.
- Locations for the new facilities can be selected from a finite set of candidate locations.
- All customers are aggregated to geographic demand points.

Customers Behavior

- **Binary model**
  The full demand of a customer is served by one facility – the most attractive one. It may occur that there are more than one facility with maximum attraction. If all the tied facilities are owned by the entering firm, then the firm captures the full demand of the customer, but if a part of the tied facilities are owned by its competitors, it is assumed that the entering firm captures a fixed proportion of customer's demand.
- **Proportional model**
  The customers patronize all the facilities in proportion to facility attraction.
- **Binary proportional model**
  Each customer has associated a fixed distance radius (attraction threshold) where they can spend their demand power. The higher the minimum attraction threshold, the smaller the radius of distance. If there are facilities located within this radius, the proportional rule can be applied and their demand will be served by all these facilities in proportion to their attractiveness (inversely proportional to distance). If there are no facilities located within this radius, then the binary rule should be applied and their demand will be divided equally among all facilities most attractive to this customer (the closest).



Numerical Experiments

- Genetic Algorithm (GA) has been applied to solve the formulated problem.
- Real geographical data: coordinates and population of 10,000 municipalities in Spain.
- The distances between demand points and facilities have been calculated in kilometers using great circle principle – Haversine distance.
- Preexisting facilities were located in 10 most populated demand points
  $$F = \{1, 2, \dots, 10\}.$$
- One hundred most populated demand points were considered as candidate locations for the new facilities
  $$L = \{1, 2, \dots, 100\}$$
- Equal qualities were set for all preexisting and new facilities
  $$q_j = 1, \forall j \in F \cup L$$
  in order to focus on the distance factor only when evaluating attraction of a facility.
- Four different threshold of attraction values were investigated:
  - $A_i = 0.01$, which is equivalent to 99 kilometers;
  - $A_i = 0.02$, which is equivalent to 49 kilometers;
  - $A_i = 0.05$, which is equivalent to 19 kilometers;
  - $A_i = 0.10$, which is equivalent to 9 kilometers.
- Due to stochastic nature of the algorithm 100 independent runs were performed and statistical estimates were calculated.

Results

Average results obtained for different threshold values, expressed in percents from the total markets share available in the geographical area, are presented in the table below.

Threshold	Total	Proportional	Binary
0.01	30.85 (±0.013)	20.81	10.04
0.02	30.83 (±0.007)	15.34	15.49
0.05	31.52 (±0.008)	11.13	20.39
0.10	30.79 (±0.017)	7.49	23.30

One can see from the table, the total market share of the new facilities is about 31% from the total market share value with standard deviation varying from 0.007 to 0.017. When the threshold values is 0.01 (100 km), two thirds of the total market share were obtained following the proportional customer behavior rule while the remaining third was obtained by the binary customer behavior rule. When the threshold values is increased to 0.02 (50 km), then almost the same market share of the new facilities are attracted almost equally by the proportional and the proportional customer behavior rule. Further increment of the threshold value makes the binary rule dominant against the proportional customer behavior rule.

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