# Facility Location with Ranking of Location Candidates Using High-Performance Computing Systems

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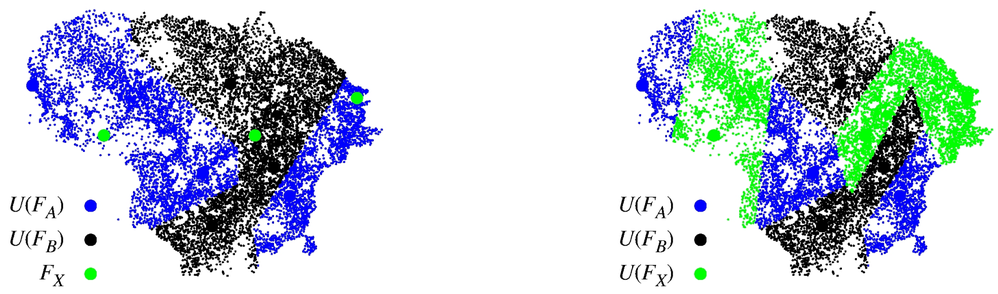
## Discrete Competitive Facility Location

- 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.

## 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 $l_i$:
  $N(l_i) = \mid \{X \in P : l_i \in X\} \mid$
- 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.

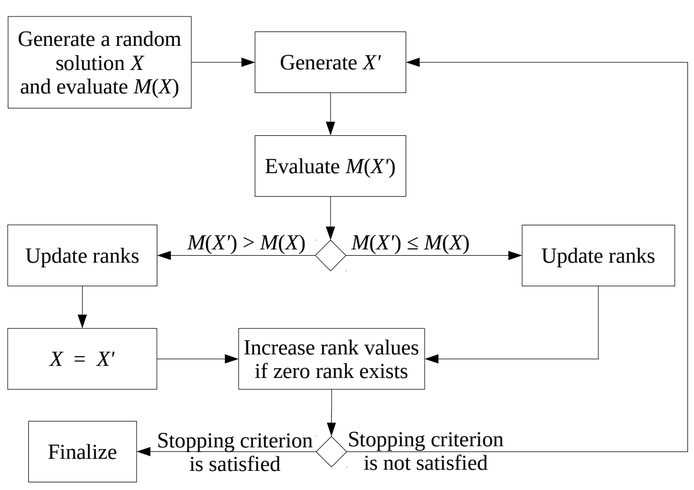
## Customer Behavior Models

- **Binary model**. The buying power of each demand point is assigned to a single facility – the most attractive one. In case of ties the entering firm captures a fixed proportion of customer's demand.
- **Proportional model**. The buying power of each demand point is split between all the facilities in proportion to their attraction.
- **Pareto-Huff model**. 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. The demand is split proportionally with the attraction that customer feels by these facilities.

## Numerical Experiments

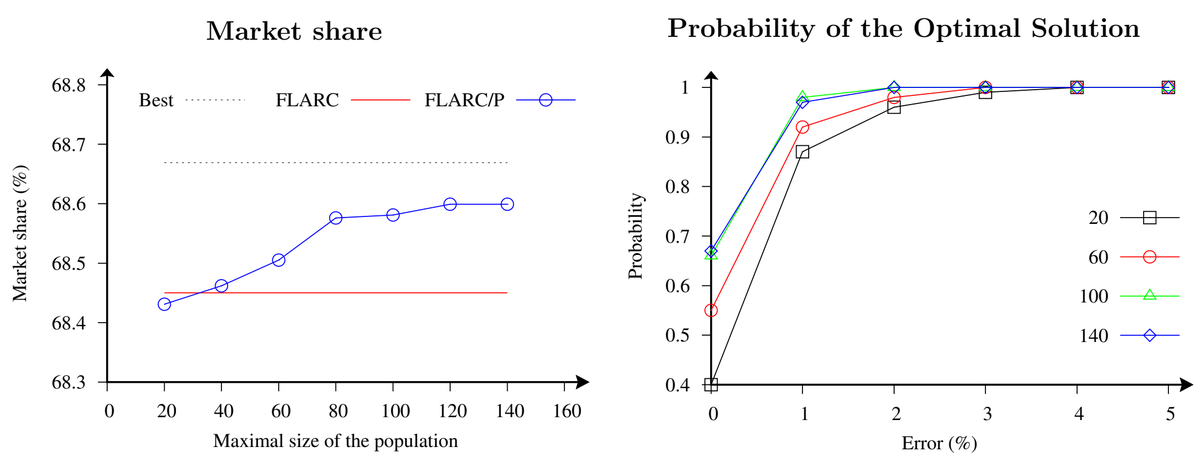
- Different instances of discrete competitive facility location problem considering Pareto-Huff customer behavior model.
- The set of demand points represents 589 largest municipalities in Spain and 10 preexisting facilities located in 10 largest demand points.
- The goal: choose locations for 3 and 10 new facilities from the set of 500 candidate locations with the budget of 10,000 objective function evaluations. All experiments were performed 100 times and average results were analyzed.

## Ranking-based Algorithm for Facility Location




- $X$ – the best solution found so far.
- $X'$ – newly generated solution.
- $M(\cdot)$ – objective function (market share) subject to maximize.
- Rank – a numeric value defining how candidate location is promising.

## Results: Facility Location Algorithm with Population



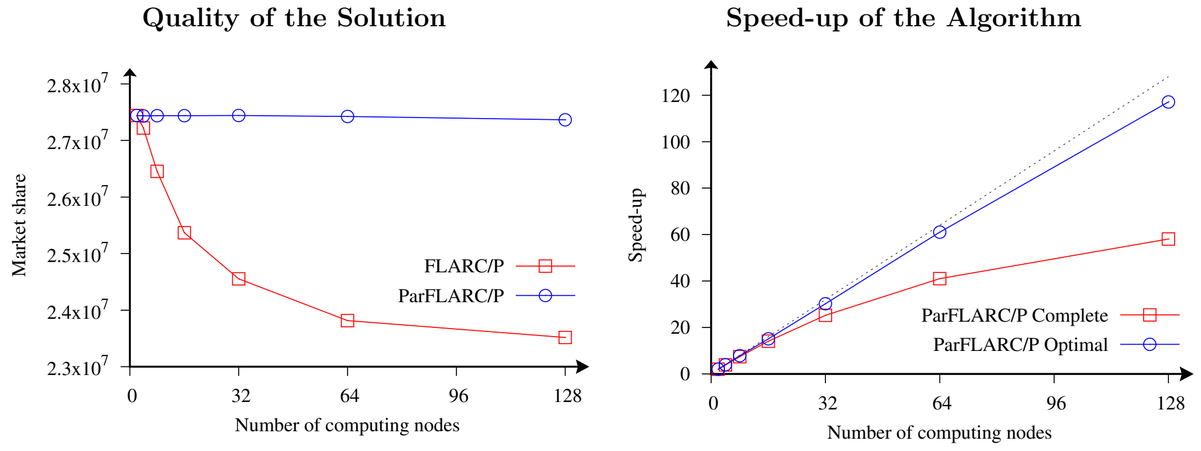

## Population in Ranking-based Algorithm for Facility Location

- The population $P$ with the maximal size $max_P$.
- The first and the last elements are the best ($X^{(b)}$) and the worst ($X^{(w)}$) solutions found so far.

## Generation of New Solutions

- The new solution is generated by changing elements of the solution sampled from the population.
- The $i$-th solution in $P$ has its own probability $\pi_i$ to be sampled, which is proportional to its fitness.
- 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.

## Results: Parallel Facility Location Algorithm with Population




- **ParFLARC/P Complete** – Parallel FLARC with exchange of the complete population.
- **ParFLARC/P Optimal** – ParFLACC/P with exchange of the new solutions only.