Optimization Problem for EV Charging Station Placement

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The algorithm aims to find the optimal locations for new electric vehicle (EV) charging stations in Boulder, Colorado, based on a dataset containing information about the usage of existing charging stations. It accounts for the energy consumption of each charging station and the projected increase in the number of EVs on the road in the future.

Given a set of weighted points $X = \{x_1, x_2, \ldots, x_n\}$, where each point represents a unit of energy consumption, and a set of existing charging stations $E = \{e_1, e_2, \ldots, e_m\}$, find a set of new charging stations $C = \{c_1, c_2, \ldots, c_p\}$ that minimizes the objective function:

$$\min_C \sum_{i=1}^{n} \left(\min_{j=1}^{p} \left(d(x_i, c_j)^2 + \frac{\alpha}{\min_{k=1}^{m} d(x_i, e_k)} \right) \right) \tag{1}$$

where

- $d(x_i, c_j)$ represents the Euclidean distance between point x_i and new charging station c_j,
- $d(x_i, e_k)$ represents the Euclidean distance between point x_i and existing charging station e_k,
- n is the number of weighted points, with each point weighted by energy consumption and the projected increase in the number of EVs,
- m is the number of existing charging stations,
- p is the number of new charging stations to be placed, and
- α is the penalty factor, controlling the influence of the penalty term on the clustering process.

The objective function consists of two terms: the squared Euclidean distance between points and new charging station locations, and a penalty term that discourages placing new charging stations too close to existing ones. By minimizing this objective function, the algorithm finds new charging locations that cater to the projected increase in EV usage while avoiding redundancy in the placement of new charging stations.