Variations of Base Station Placement Problem on the Boundary of a Convex Region

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Abstract

Due to the recent growth in the demand of mobile communication services in several typical environments, the development of efficient systems for providing specialized services has become an important issue in mobile communication research. An important sub-problem in this area is the base-station placement problem, where the objective is to identify the location for placing the base-stations. Mobile terminals communicate with their respective nearest base station, and the base stations communicate with each other over scarce wireless channels in a multi-hop fashion by receiving and transmitting radio signals. Each base station emits signal periodically and all the mobile terminals within its range can identify it as its nearest base station after receiving such radio signal. Here the problem is to position the base stations such that each point in the entire area can communicate with at least one base-station, and total power required for all the base-stations in the network is minimized. A different variation of this problem arises when some portions of the target region is not suitable for placing the base-stations, but the communication inside those regions need to be provided. For example, we may consider the large water bodies or the stiff mountains. In such cases, we need some specialized algorithms for efficiently placing the base-stations on the boundary of the forbidden zone to provide services inside that region.

In our model, all the k base-stations are similar; in other words, their range/power-requirement are same. We shall consider two variations of the problem where the region P and the number of base-stations k are given a priori.

region-cover(k)**:** Place the base-stations on the boundary of P to cover the entire region P.

vertex-cover(k)**:** Place the base-stations on the boundary of P to cover the vertices of P.

We first present a polynomial time algorithms for the *vertex-cover(2)* and *region-cover(2)* problems, where the base-stations may appear any where on the boundary of P. We also show that, if a pair of edges of the polygon is specified on which the base-stations can be installed, then the *vertex-cover(2)* and the *region-cover*(2) problems can be optimally solved in polynomial time. More specifically, the time complexity of these two problems are $O(n \log n)$ and $O(n^2)$ respectively. Next, we consider a restricted version of both the problems where all the k (≥ 3)

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base-stations can be placed on an edge of P. The objective is to minimize the (common) range of the base-stations. Our proposed algorithm for the *restricted vertex-cover(k)* problem produces optimum result in $O(min(n^2, nk \log n))$ time, whereas the algorithm for the *restricted region-cover(k)* produces an additive ϵ approximation result in the sense that if ρ is the optimum solution, then our algorithm returns a value less than or equal to $\rho + \epsilon$. The time complexity of our algorithm is $O(n \log \frac{\Pi}{\epsilon})$, where Π is the perimeter of the polygon P. Finally, we will describe a heuristic algorithm for the unrestricted *region-cover(k)* problem, where $k \geq 3$. Experimental results demonstrate that our proposed algorithm runs fast and produces near optimum solutions.