Resource Management in Cellular Networks

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Abstract

Now a days cellular phone companies are facing a lot of problem regarding resource management. Resources for establishing cellular networks are very expensive. Antennas are one these resource. Cellular companies are facing problem regarding proper management of these antennas. In this paper we address the issue of antenna placement problem (APP) to reduce the number of antennas in a specific area. We propose a self tuning algorithm that identifies the location of antennas to be placed in the desired coverage area using minimum number of antennas.

Digital Elevation Maps for the proposed coverage area are processed to create a candidate location matrix where antennas can be placed. This matrix provides a mean to isolate areas where antenna deployment is restricted due to Legal or other concerns. This paper utilizes omni directional antennas and provides x, y coordinates of the proposed location in the area of interest.

Keywords: Antenna Placement Problem (APP), Digital Elevation Models (DEM), optimal cellular Coverage

1. Introduction

Setting up Cellular network in a specific area not only requires exclusive frequency assignment but also require optimal placement of antennas. To provide full area coverage using minimum number of antennas is itself a challenging task. Within the selected geographical location where the Cellular network is to be installed, engineers require the minimum number of antennas to be installed, their type and location of installation.

This paper provides a solution to the Antenna Placement Problem (APP) and proposes algorithm to optimize the coverage of an area. This paper does not take into consideration the Frequency Assignment Problem (FAP) that minimizes electromagnetic interference due to multiple use of same frequencies in different parts of the network. Although FAP has been intensively investigated, little work has been done for APP.

One reason is that the APP is much more difficult to model, and even a simple model - treating only coverage of the working area - can be shown to be NP-Hard.

Furthermore APP is a multi-objective and constrained problem with all its known difficulties.

The objectives are to minimize number of antennas used and to have practically feasible location of placement to provide full area coverage.

The development of an appropriate model is one of the most difficult tasks in solving complex real world problems. The model for the APP used in this project is the result of several loops of design, evaluation and redesign. The quality of solutions of the APP is assessed by two constraints, which deal with coverage and resource optimization. They address economical and technical aspects of the project.

Digital Elevation Map (DEM) gives Latitude, Longitude and Elevation information of the area where the Cellular networks is to be deployed.

The complete area is divided into smaller squares to simplify the problem. We can provide deterministic coverage by placing an omni directional antenna in each square, provided the size of the square is less than the range of the antenna.
Computational geometry and graph theoretic techniques, specifically the Voronoi diagram can also be applied to find the best and worst case coverage as explained in [1].

2. Constraints & Objectives

A feasible solution has to fulfill the following two constraints:

- **Antenna Constraint (AC):** Minimize the number of Antennas,
- **Coverage Constraint (CC):** Points in the covered area receives signal above a certain threshold.

The algorithm assumes that the omni-directional antenna covers eight adjacent grid squares around it. The size of these squares depends on the coverage radius of the antenna used.

3. Antenna Location selection Scheme

We have implemented an antenna placement scheme by considering the area of interest as a grid map. The scheme provides information about the locations of the antennae in terms of the x and y coordinates of the grid points. Since the optimal solution for this problem is NP-Hard, a heuristic algorithm for large maps is also required.

Our algorithm first tries to get all the possible points in the whole area where antenna can be placed. Once we have these potential areas, it is possible to use the branch and bound method, to go through all the possible positions. While we’re going through all the different possibilities, we keep track of the lowest number of antennas needed.

After the first possible antenna placement is found, the lowest number of antennas for this candidate location is calculated, we use this value as a bound for all future calculations. For example, if the first possible point returns the lowest numbers of antennas to be 3, then the branch should not have to go down any further than three.

This bounding technique will save a large percentage of calculations. This method covers all possibilities and returns the smallest number of antenna coverage.

Following figure shows a 4x5 area with 7 possible antenna locations indicated by the ● sign.