Variable Neighborhood Search for the Minimum Interference Frequency Assignment Problem

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1 Introduction

The frequency assignment is an important task in the design of radio networks. Let us consider a GSM network $N$ composed of a set of $nc$ cells: $C = \{C_1, C_2, \ldots, C_{nc}\}$. Each cell required a number of frequencies which is defined by the number of transceivers $TRX$ or traffic demand $D_i = \{1, 2, \ldots, x\}$ An interval of operational frequencies: $[F_{max} - F_{min}]$. Further, consider a matrix: $MCo[nc][nc]$ which contains the Co-channel rate generated if the $j^{th}$ TRX of cell $j$ uses the same channel ($f$) of the $j^{th}$ TRX of cell $i$. The matrix $MAdj[nc][nc]$ which contains the Adjacent-channel rate generated if one TRX of cell $j$ use an adjacent channel ($f+1$) or ($f-1$) to the channel ($f$), used by a TRX from cell $i$. So we are facing the following Frequency Assignment Problem (FAP): Given a list of TRX, an interval of operational frequencies, a matrix of Co-channel and Adjacent channel interference, the goal is then to assign a frequency to each TRX, with minimum Co-channel and Adjacent-channel interferences generated by the reuse frequency principle. The Minimum Interference-FAP is the problem of finding an assignment for each TRX that minimizes the cost function given in formula (1) and taken from[1].

$$\text{Minimize } \sum_{i=1}^{NC} \sum_{j=1}^{NC} (Y_i \times \text{Interfco}(i,j) + Z_i \times \text{Interfadj}(i,j)) \times w_i \quad (1)$$

The objective function (1) minimizes the overall interferences which equals the total Co-channel interferences and the total Adjacent interferences rates, a weight ($w_i$) associated to Cell $i$ due to amount of traffic carried. The variables $Y_i$ ($Z_i$) takes the value 1 if TRX from cell $i$ and $j$ operates on the same (Adjacent) frequency, 0 otherwise. The $\text{Interfco}(ij)$ ($\text{Interfadj}(ij)$) is the Co (Adjacent) adjacent channel rate generated between the cells $i$ and $j$.

In this paper, we develop a VNS algorithm for the MI-FAP. Starting from an initial solution $X$, we denote by $N_k(X)$ the set of solutions in the $k^{th}$ neighborhood of $X$. Until the stopping criterion is not met, we do this: the search starts from the first neighborhood $N_1(X)$ of the current solution. A solution $X'$ is generated by a random perturbation in the current neighborhood, a local search is applied on the $X'$ to obtain a locally optimal solution $X''$. If $X''$ is better than
the current solution X, then replace X by $X''$, and start again with k=1 for the new solution. Otherwise the current solution X is not modified, k=k+1 and the loop are performed with this new neighborhood. In the local search we choose to generate the neighborhood by modifying the conflicting node: we find the frequency assigned to a TRX, that caused the most interferences with its neighbors and we move it, by assigning to it the less used frequency.

2 Computational Experiments

This section gives some preliminary results. The java programming language is used to implement the VNS algorithm for the MI-FAP. In this paper, we use the realistic data COST259 given by[2]. Due to the non-deterministic nature of VNS and GA algorithms, 10 runs have been considered for each Benchmark and for each algorithm. The average results found by each method are reported.

Table 1. Results obtained for all instances of the Siemens Benchmarks

<table>
<thead>
<tr>
<th>Siemens1</th>
<th>Siemens2</th>
<th>Siemens3</th>
</tr>
</thead>
<tbody>
<tr>
<td>Cost</td>
<td>%Adj ChaV</td>
<td>%Co ChaV</td>
</tr>
<tr>
<td>VNS(02)</td>
<td>58.71 4.36</td>
<td>3.05</td>
</tr>
<tr>
<td>VNS(03)</td>
<td>39.46 4.36</td>
<td>2.81</td>
</tr>
<tr>
<td>VNS(04)</td>
<td>30.28 3.92</td>
<td>1.76</td>
</tr>
<tr>
<td>GA</td>
<td>282.03 4.48</td>
<td>4.33</td>
</tr>
</tbody>
</table>

Table 1 shows clearly the performance of VNS in reaching good quality solutions for all the Siemens benchmarks instances compared to the GA. VNS explores different neighborhood which permits to locate and identify efficiently good solutions with the lowest level of interferences. We plan to validate the VNS approach on other benchmarks for MI-FAP and we shall conduct other comparisons with others techniques.

References