On finding the signal to interference ratio for the DCA Problem

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Abstract

This note accompanies the DCA algorithm [1] proposed by Daniels et. al. The algorithm relies on assigning channels while satisfying a cumulative interference criteria. All channel assignments must satisfy the constraint
\[ \sum_{j \neq i} S(\vec{c}_i, \vec{c}_j) \geq B, \]
where \( S(\vec{c}_i, \vec{c}_j) \) represents the signal measured at cell \( \vec{c}_i \) due to a transmitter in cell \( \vec{c}_j \), both operating over the same channel. The approach for determining \( B \) so as to also satisfy required geographic reuse distance constraints is based on applying a greedy sequential channel assignment strategy. The algorithm iterates over increasing values of the threshold \( B \) to determine ranges where the minimum reuse distance is 2 and 3 respectively in a \( 7 \times 7 \) square cellular grid.

1 Determining threshold \( B \)

In our algorithm the minimum carrier-to-interference (C/I) ratio threshold is represented by \( B \). Denote the cellular locations by the vector \( \vec{c}_i, i = 1, \ldots, 49 \). Let \( S(\vec{c}_i, \vec{c}_j) \) denote the strength of the signal at \( \vec{c}_i \) due to a transmitter at \( \vec{c}_j \) and it satisfies Eqn. 1 below:

\[ S(\vec{c}_i, \vec{c}_j) = \frac{1}{(|\vec{c}_i - \vec{c}_j|)^\alpha} \]  

(1)

In Eqn. 1, \( \alpha \) is a path-loss exponent and \( |\vec{c}_i - \vec{c}_j| \) is the geographic (Euclidean) distance between cell \( \vec{c}_i \) and cell \( \vec{c}_j \). The ratio requirement is shown below in Eqn. 2:

\[ \frac{S(\vec{c}_i, \vec{c}_j)}{\sum_{j \neq i} S(\vec{c}_i, \vec{c}_j)} \geq B \]  

(2)

where the summation in the denominator represents the sum of interfering signal strengths.

The specification of the interference signal \( S(\vec{c}_i, \vec{c}_j) \) generated at \( \vec{c}_i \) due to transmitters located in \( \vec{c}_j \) may be derived from any channel model. In this work, a simple path loss model is specified based on the distance \( |\vec{c}_i - \vec{c}_j| \) and path loss exponent \( \alpha \) as given in Eqn. 1. All transmitters are assumed to be transmitting at the same power level. If cells are subject to the effects of fading and shadowing and the transmitters implement power control to counteract these effects, their transmission power level can change. In such a case each cell may be modeled by a function that describes the spread of transmission power in space.

1.1 Interference Threshold Calculation

In the simulations performed two values \( B = B_2 \) and \( B = B_3 \) of the \( C/I \) threshold \( B \) are chosen. The indices represent the largest reuse distance just less than \( r = 2 \) and 3 respectively. These values are also associated with cluster sizes of \( 2 \times 2 \) and \( 3 \times 3 \), respectively. Channel reuse is allowed at distances of 2
and 3 in each case. The sequential greedy channel assignment algorithm described below is applied to find assignments on a $7 \times 7$ square cellular grid. The demand in each cell is set to one. Solutions are obtained for $\alpha = 3.5$ and $4000 \leq B \leq 175000$. For each value of $B$ in this range, the minimum, maximum and average reuse distance is calculated across all of the frequencies used to obtain an assignment.

**GREEDY SEQUENTIAL ASSIGNMENT ALGORITHM:**

1. For each cell $i = 1$ to $c_{\text{max}}$
   - $D \leftarrow \sum_{i=1}^{c_{\text{max}}} D_t(\vec{c}_i)$
   - For each cell $i = 1$ to $c_{\text{max}}$
     - $\delta_1(\vec{c}_i) \leftarrow D_t(\vec{c}_i)$
   - While $D > 0$
     - For each cell $i = 1$ to $c_{\text{max}}$
       - If $\delta_1(\vec{c}_i) > 0$
         - $f_k \leftarrow$ channel of least number satisfying Eqn. 2
         - $A(\vec{c}_i, f_k) \leftarrow 1$
         - $\delta_1(\vec{c}_i) \leftarrow \delta_1(\vec{c}_i) - 1$
         - $D \leftarrow D - 1$

2. Return $A$

Fig. 1 shows the change in the minimum reuse distance as the threshold $B$ is increased. It is seen that thresholds approximately in the range $12750 \leq B \leq 34700$ constrain $r = 2$, while thresholds in the range $122400 \leq B \leq 144300$ satisfy the condition for $r = 3$. 

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**Figure 1:** Minimum reuse distance as a function of $C/I$ threshold $B$. 

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References