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Correlation-based spectrum sensing in presence of mobility

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Introduction

The work presented here is the result of the STSM which took place in Rome from 2nd to 15th of December 2012 and was found by COST IC0902.

Spectrum sensing is crucial for cognitive radio devices, however, utilization of only one sensing node has been proved to be not sufficient enough for safe coexistence between primary and secondary users. Thus, reliable spectrum sensing involves cooperation between nodes. In that case every node senses the spectrum, and sends information to the fusion center where the global decision is made. Due to limited energy budget and necessity of minimalizing sensing-information overhead in the network it is highly recommended to select nodes for sensing [1]. Moreover, in the correlated environment it is remunerative to select uncorrelated nodes in order to improve perceived capacity [2].

One of the correlation-based node selection solution, described in [3], provided results that proper selection of only 10 out of 100 nodes gives much less overhead information and slightly lower probability of detection and a little higher probability of false alarm values. However, the good approach was obtained in very favorable conditions. The authors assumed constant presence of Primary User (PU) and signal-to-noise ratio at level of 10 dB. An interesting research field is to examine how the correlation-based selection works in the realistic conditions such as low-SNR, random PU presence and mobility scenarios.

Solution

In the network M nodes are assumed to send N decisions of spectrum sensing. $\mathrm{S_i(k)}$ denotes the *k*-th decision of the *i*-th node (1):

$$\mathrm{S_i(k)} = \begin{cases} 1, & \text{when } \mathrm{H_1} \text{ is declared} \\ -1, & \text{when } \mathrm{H_0} \text{ is declared} \end{cases} \qquad (1)$$

where H_1 and H_0 are the hypotheses of presence and absence of PU, respectively. On the base of N transferred to fusion center decisions, the correlation coefficients are defined for all pairs of nodes in the network (2):

$$\gamma_{\mathrm{i,j}} = 1 - \frac{\sum_{\mathrm{k=1}}^{\mathrm{N}} |\mathrm{S_i(k)} - \mathrm{S_j(k)}|}{2\mathrm{N}}. \qquad (2)$$

Then, the Γ matrix of size $\mathrm{M \times M}$ is built. The diagonal elements of matrix are the self-correlation coefficients equal to ones, besides, Γ is a symmetry matrix.

The solution is based on grouping correlated nodes. If only one pair of nodes has γ above α correlation threshold (which is assumed to be 0.95), then these nodes are grouped. In a case, where more than two nodes are correlated, they can be clustered provided that every node with each other in proposed group is correlated (their γ are larger than α). If so, nodes are grouped. The operation is done repeatedly until the correlation between any ungrouped nodes is smaller than α threshold. Finally, the node with the highest probability of detection from every group and all of ungrouped nodes are selected to sense the spectrum.

Model

Correlation-based node selection scheme has been investigated by mean of computer simulation carried out in the Matlab environment. In the model 100 nodes is randomly distributed in the square area of 200 m side. Every node is assumed to have the same probability of false alarm and therefore the same sensing threshold. Received power is compared to the threshold and sensing decision is made. The power for a given node was approximated according to formula:

$$\text{channel}|_{\text{dB}} = \text{path loss}|_{\text{dB}} + \text{fast fading}|_{\text{dB}} + \text{shadowing}|_{\text{dB}} \qquad (3)$$

Path loss depends on carrier frequency and distance between secondary and primary users. It is time invariant, so its value for 1000 sensing samples is constant. The fading channel is independent between nodes but it is time variant. For shadowing, the 50 m-decorrelation distance has been assumed. Hence square area of 200 meters side has been divided into 16 50 m-long squares where shadowing values are constant. As a result, shadowing value for a given node depends on position of node.

Results

Global probability of detection versus signal-to-noise was simulated (Fig. 1). Two situations have been considered: a) all nodes are allowed to vote (Qd); b) node selection is performed (Qd chosen). Two channel scenarios were applied: slow pedestrian (Doppler shift =6 Hz) and fast (Doppler shift =100 Hz).

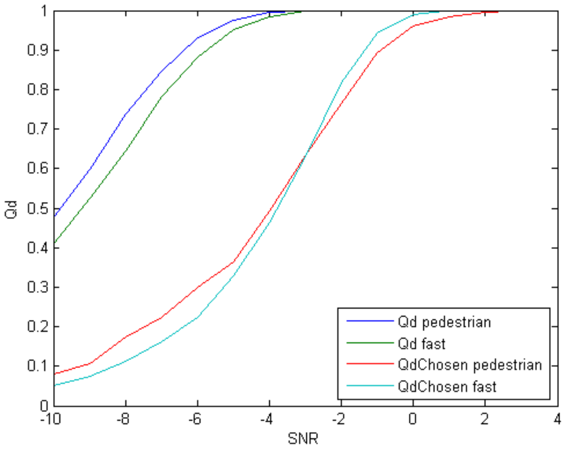

Fig. 1 Global probability of detection for all and selected nodes for pedestrian and fast channel

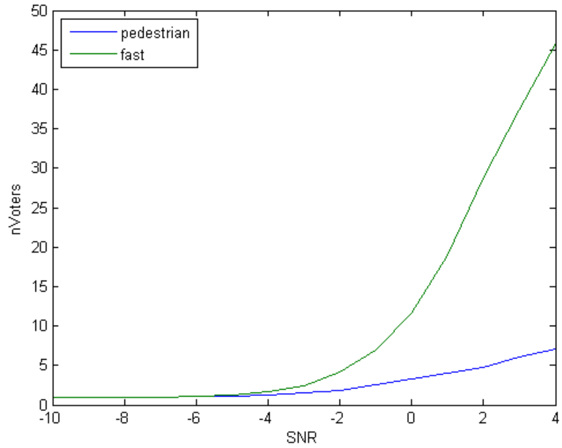

Fig. 2 Number of selected nodes for pedestrian and fast channel

One can easily observe that selection based scheme guarantees lower global probability of detection. On the other hand node selection provide lower number of false alarms and reduced overhead. Detection quality is highly correlated with the number of voters (Fig. 2). For SNRs below -4 dB only a few nodes are selected due to very high correlation (about 100%) in the network. As a result, few groups is formed and a couple of nodes are allowed for sensing.

References:

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