Implementation of a Cooperative Spectrum Sensing System using GNU Radio and USRP

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1 Introduction

Studies have shown that cooperative spectrum sensing, which utilizes multiple sensor nodes, is one method to achieve good probability of detection in environments subject to low SNR, multipath and shadowing effects. In this work, a spectrum sensing system has been implemented using the GNU Radio software radio platform, and the Universal Software Radio Peripheral (USRP) hardware. GNU Radio provides signal processing blocks implemented in C++ programming language, and are connected to each other in Python script. The USRP is the baseband front-end, and RF daughter board XCVR2450 which is mounted on the USRP is able to cover frequency ranges of 2.4 to 2.5 GHz, and 4.9 to 5.9 GHz. Details of the GNU Radio and USRP setup can be found in [1]. The energy detection approach is used in this work.

2 System Setup

The python program 'usrp_spectrum_sense.py' which comes pre-installed with GNU Radio, has been modified to output the averaged periodogram which will be used in this work. In order to sense the frequency spectrum across a wide bandwidth, several outputs from GNU Radio are combined in Matlab. To calculate the threshold , spectrum sensing is performed without any input signal to obtain the noise variance [1]. Then, the data is compared with the threshold to determine the presence of a signal. As shown in Fig. 1, the sensing results of each sensor node are sent to the head node using wireless LAN in infrastructure mode, and TCP protocol is used to ensure the data is received reliably. In the head nodes, cooperative sensing algorithm is performed. The head nodes will use wireless LAN in ad-hoc mode to transfer decision results among head nodes, and to the central database. Performing real-time cooperative spectrum sensing requires the synchronization of all nodes, so that we can confirm the result of cooperative sensing at one particular time. The Network Time Protocol (NTP) has been utilized to achieve synchronization up to an accuracy of a few milliseconds. The sensor nodes will wait until the head nodes send information about the sensing time before starting.

3 Experiment Setup

An experiment was performed to evaluate the performance of USRP & GNU Radio as sensor nodes. A signal generator, which was connected to the daughter boards using a coaxial cable, was used to generate a sinusoidal wave at 5.003 GHz. The sensor nodes sensed the frequency spectrum with a bandwidth of 1 MHz, 31.25 kHz FFT bin resolution, and each FFT bin output was averaged 3125 times. To accurately estimate the probability of detection P_D, the measurement was repeated 1000 times for various SNR values. Decision results of 3 individual sensor nodes were combined to perform cooperative sensing based on hard (OR-rule) and soft decision [2]. From Fig. 2, it can be seen that the performance of this setup is similar to the theoretical curve but with a decrease in performance by 1∼2 dB. This is predicted to be caused by limitations such as instrument error.

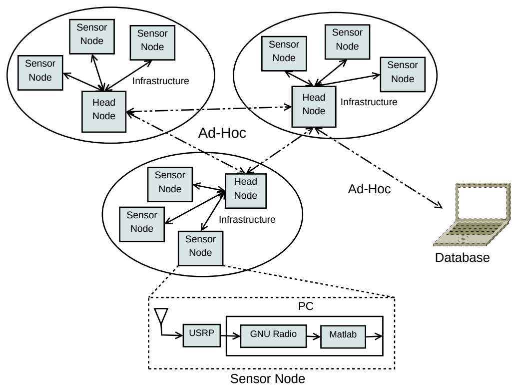

Figure 1: System Architecture

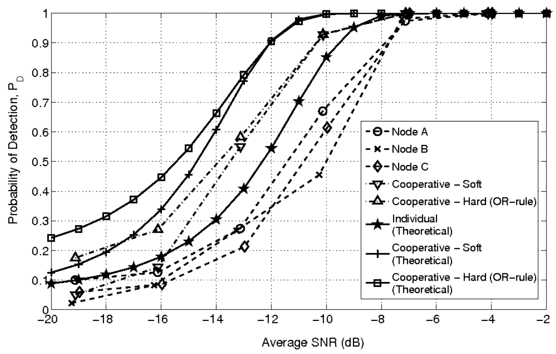

Figure 2: Comparison of P_D for Individual & Cooperative Sensing

References

[1] M.A. Rahman, et al. , "Development of Spectrum Sensing System with GNU Radio and USRP to Detect Emergency Radios," *IEICE Technical Report*, SR2009-57, October 2009.

[2] A. Ghasemi, E.S. Sousa, "Collaborative Spectrum Sensing for Opportunistic Access in Fading Environments," *First IEEE Proc. of DySPAN'05*, November 2005.