Integration of Propagation Modelling Assets for Enhancing Spectrum Sensing Capabilities in Cognitive Communication Networking

F. A. Qazi, A. S. Das*, Z. Yun, and M. F. Iskander
Hawaii Center for Advanced Communications, College of Engineering
University of Hawaii at Manoa

Robust spectrum sensing and efficient cognitive communication networking (C^2N) operation in various terrain environments require that the cognitive radio be proactive and dynamic in selecting the optimal sensing parameters for the current and future locations of mobile units. In spectrum sensing, the detector performance is characterized in terms of detection probability (the rate of C^2N correctly sensing a busy channel and avoiding to use it), P_d and false alarm probability (the rate at which a free channel is mistakenly identified as busy), P_{fa} parameters. It is worth mentioning that providing higher detection probability should take precedence over providing lower false alarm rates, because a low P_d leads to harmful interference which, in turn, adversely affects other mobile devices whereas a high P_{fa} results in the C^2N not using that specific channel.

Propagation modeling and a realistic channel characterization represent two very important prerequisites for efficient setting of the sensing communication parameters in a receiver. However, the sensing parameters are often set to fixed values irrespective of environment using statistical methods, thus resulting in a fluctuating and unreliable sensing performance. To enable accurate, site specific and computationally efficient setting of these parameters in C^2N, we have focused our efforts, so far, on the development of fast, accurate and geospatial resource based propagation modeling capabilities based on variety of computational methods including ray tracing, parabolic equation solution, and full wave analysis using finite-difference time-domain (FDTD). In this paper, we describe the integration of these propagation modeling assets in establishing real time receiver parameters and settings in urban cognitive communication environment. The developed approach is based on employing a multi-level threshold setting mechanism based on the path loss, angle of arrival/departure and delay spread information provided by the site specific propagation modeling to ensure a fixed probability of detection. The receiver parameters such as window size and threshold are adjusted according to the environment predicted by propagation modelling.

Specifically we will model a doubly-selective MIMO wireless channel to calculate the channel matrix using the propagation modeling parameters. The obtained channel matrix will then be used for a MIMO-OFDM system receiver. In parallel, a stochastic channel matrix will also applied to the receiver of a MIMO-OFDM system and the performances of both MIMO-OFDM systems will be compared. The results will show that a high detection rate can be maintained for a mobile cognitive radio in various terrains when the thresholds are set based on the information provided by the site specific propagation modelling. If, however, the performance is not satisfactory, it could be improved via obtaining a channel matrix with a higher level of detail. An application of MIMO systems, i.e. Active Wireless Sensing (AWS) is modeled. AWS consists of two major parts: an ensemble of wireless sensor (which are widely separated) and a Wireless Information Retriever (WIR). The sensor nodes sense the environment and communicate with the WIR (which acts as a base station) using wireless front ends. For uplink communication (from the sensors ensemble to the WIR) the AWS will use a linear Minimum Mean Squared Error (MMSE) multiuser detector. This will utilize the channel matrix obtained via the aforementioned propagation modeling tools. Such a model will optimally adjust the receiver characteristics for the MMSE multiuser detection scheme and provide high probability of detection in communication systems while maintaining a low probability of false detection and interference.